Evaluation of Navy Inventory Decision Rules Utilizing the IBM Inventory Management Simulator

FINAL REPORT

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INTRODUCTION

BACKGROUND

Contract NONR 3742(00), performed by the Federal Systems Division of the International Business Machines Corporation for the Bureau of Supplies and Accounts, is a continuation of IBM's Independent Research and Development (IRAD) Program, Task 0453, completed 15 September 1961, in which the utility of using a computerized inventory control simulator as a management tool in the military supply system was proven.

During the conduct of IRAD Task 0453, the IBM Inventory Management Simulator (IMS) was used to simulate the inventory control system in operation at the Ships Parts Control Center (SPCC), Mechanicsburg, Pennsylvania. Demands for a small sample of items maintained at this supply demand control center were used as input to the simulation. The complex set of decision rules used was programmed into the IMS along with other available data affecting inventory control. The simulation was run with various combinations of these decision rules, with results being evaluated so as to achieve that combination of decision rules that best met management objectives.

The present contract involved programming additional inventory rules into the simulator. The simulation was then used to evaluate the effect of two dissimilar inventory rules on the same supply system. The final objective was to vary the parameters of one set of rules so that the system would perform within a given tolerance of the performance obtained by use of the other set of rules.

THE INVENTORY MANAGEMENT SIMULATOR (IMS)

The IMS is a computer program consisting basically of a series of routines logically associated with such inventory factors as review period, order point, order quantity, lead time, safety stock level, and forecasting. By properly combining, and sometimes modifying these routines, virtually any inventory control system may be simulated.

The major functions of the IMS are summarized as follows:

(a) Demands may be either supplied from historical records or synthesized by a demand generator.

(b) Forecasting may be done by exponential smoothing or moving average with the option of trend and seasonal corrections.

(c) Order point and order quantity calculations may be done either after each transaction or on a periodic basis.

(d) Material flow is controlled primarily through use of the on-hand and on-order amount. When material is ordered, the amount is placed in a queue. At the conclusion of the appropriate lead time, this amount is removed from the queue and added to the on-hand quantity.

(e) Policy evaluation is done on an item basis and for a group of items. At the end of each simulation run, a printout is generated showing level of inventory, costs, and service provided.

USE OF THE IMS AS A MANAGEMENT TOOL

The Inventory Management Simulator is a very powerful research and analysis tool for use in the areas of supply management. A built-in flexibility allows modification to simulate virtually any type of inventory system by simply programming the specific inventory rules of a supply system and arranging the logical routines to conform to the real-life situation. By using actual historical inventory transactions or generated transactions as input to the simulation, several years of detailed activity of a specific inventory system may be compressed into a few minutes of simulation. An evaluation of the specific inventory system can then be made with the aid of the simulation results.

Section 2

PROBLEM SCOPE

STATEMENT OF PROBLEM

The basic objective of this study was to utilize the Inventory Management Simulator as a tool to match the results of using certain inventory decision rules developed by Stanford Research Institute (SRI) with the results obtained by using other inventory decision rules developed by Planning Research Corp. (PRC). In particular, the SRI rules were to be varied so that the average dollar inventory and obligated funds for procurement were within a given tolerance of the results obtained by use of the PRC rules.

SCOPE OF WORK

The project was divided into five tasks. These were:

(1) Modify the routines of the basic simulator (as follows) to conform to requirements specified by the Bureau of Supplies and Accounts.

- (a) Modify the input routines so that certain type transactions common throughout the Navy Supply system could be introduced as input into this simulation.
- (b) Modify the output routines (summary results) so that a broader analysis could be made of the effect of various inventory rules on a typical Navy Inventory system.
- (c) Increase the speed of the simulator by modifying various routines.
- (d) Add to the simulator an order placement routine by which material is received into stock as a function of a variable lead time.

(2) Generate variable lead times for order placement for the specific items used in the simulation.

(3) Prepare the data for initializing item records and generate a demand tape for 24 items, to be used as input to the simulation.

(4) Program the inventory rules developed by PRC and SRI into the basic simulator. Specifically, make modifications to the PRC rules, previously programmed, and program the two specified SRI rules.

(5) Make simulation runs with the SRI rules for 24 inventory items for 104 weeks of demand history and match the results to results obtained by utilizing PRC rules.

Section 3

TECHNICAL APPROACH

The five tasks listed in Section 2 are described in detail below.

MODIFICATION OF THE BASIC SIMULATOR

The demand input subroutine was modified so that seven types of inventory transactions could be introduced into the IMS. These are:

	Type Transaction	Code
1.	Reportable/Replenishable Demand Issue	A
2.	Replenishable Demand Issue Credit	B
3.	Non-Reportable Demand Issue	H
4.	Establish Replenishable Demand Obligation	S
5.	Cancel Replenishable Demand Obligation	T
6.	Demand Debit	Y
7.	Demand Credit	Z

The output routines were modified to conform to the specified needs of BuSandA for analyzing an inventory system. The following outputs are developed and printed for an individual item summary and total system summary.

- Cost of material procured = (no. of items ordered) x (unit cost).
- Average value of on hand stock = (average inventory on a weekly basis) x (unit cost).
- Dollar velocity of annual demand = (no. of demands made upon system on an average annual basis) x (unit cost).
- Average value of lead time stock = (average of the lead time stock on a quarterly basis) x (unit cost).
- Average value of order point stock = (average of the order point stock on a quarterly basis) x (unit cost).

- Order placement cost = (no. of orders placed) x (order placement cost - $25.00).
- Total holding cost = (average inventory on a yearly basis) x (15%) x (unit cost).
- Total shortage cost (dollar base) = (no. of units on back order) x (1.00).
- Total shortage cost (unit cost base) = (no. of units on back order) x (unit cost).
- Total cost (dollar base) = (total holding cost) + (total order cost) + (total shortage cost (dollar base)).
- Total cost (unit cost base) = (total holding cost) + (total order cost) + (total shortage cost (unit cost base)).
- Service percentage = the percentage of demands that could be filled without back ordering.
- Average back order age (wk) = (no. of unit weeks in back order) ÷ (no. of units in back order).
- Back order service = the percentage of demands that could be filled that were in back order.
- Total demand for issue = cumulation of the demands that effected the issues.
- Total demand for forecast = cumulation of the demands that effected the forecasts.
- On hand (ending) = the amount of material on hand at the end of the simulation. - Not applicable to total system summary.
- Due in (ending) = the amount of material due in at the end of the simulation. - Not applicable to total system summary.
- Due out (ending) = the amount of material due out at the end of the simulation. - Not applicable to total system summary.
- Total back order weeks = number of unit weeks in back order.

Figure 1 illustrates the individual item summary while Figure 2 illustrates the total system summary.

The input routine was modified so that a block of thirty inventory transactions could be read into the simulation at one time. This increased the overall speed of the simulation.

The order placement routine was modified to allow material to be received into stock as a function of a statistical distribution of lead time.

RULE PARAMETER

RUN NO 11 PRC DISCRETE SHORTAGE FORMULA C/(CD)**.25 HOLDING RATE 0.50 LAMBDA 1.00

EXPONENTIAL SMOOTHING ALPHA 0.20

INITIAL CONDITIONS

ITEM NO 15 STOCK NO HR 2825-379-3571 ON HAND 0. MEAN ANNUAL DEMAND 11.0 ORDER QUANTITY 2.

COST $ 1830.00 MEAN LEAD TIME 77. SIGMA L 3.43 DUE IN 39. STANDARD DEVIATION 4.04 ORDER POINT 18.

RUNNING REPORT

WEEK	ON HAND	ISSUE	ORDER	B/O	AVAIL	DEMAND	LT FCST	STD DEV	Q FCST	ORD QTY	ORD PT
9	0	0	0	1	58						
13	0	0	0	1	38	5.0	19.0	4.6	3.2	2.0	21.0
15	0	0	0	2	57						
26	11	3	0	0	56	2.0	17.5	4.4	3.0	2.0	20.0
39	30	6	0	0	30	10.0	25.9	7.8	4.4	3.0	29.0
52	25	5	13	0	38	9.0	31.4	9.1	5.3	3.0	35.0
65	24	1	0	0	37	4.0	29.8	8.0	5.0	3.0	33.0
78	22	2	0	0	35	3.0	27.4	7.7	4.6	3.0	30.0
91	21	1	0	0	34	2.0	24.3	7.7	4.1	2.0	27.0
104	20	1	0	0	33	4.0	24.2	6.3	4.1	2.0	27.0

ITEM SUMMARY RESULTS

COST OF MATERIAL PROCURED	$ 23790.00	SERVICE PERCENTAGE	89.47
AVERAGE VALUE OF ON HAND STOCK	$ 32271.35	AVERAGE BACK ORDER AGE (WK)	14.0
DOLLAR VELOCITY OF ANNUAL DEMAND	$ 17385.00	BACK ORDER SERVICE	10.53
AVERAGE VALUE OF LEAD TIME STOCK	$ 43955.16	TOTAL DEMAND FOR ISSUE	19
AVERAGE VALUE OF ORDER POINT STOCK	$ 48882.11	TOTAL DEMAND FOR FORECAST	39
ORDER PLACEMENT COST	$ 25.00	ON HAND (ENDING)	20
TOTAL HOLDING COST	$ 4840.70	DUE IN (ENDING)	15
TOTAL SHORTAGE COST (DOLLAR BASE)	$ 2.00	DUE OUT (ENDING)	0
TOTAL SHORTAGE COST (UNIT COST BASE)	$ 3660.00	TOTAL BACK ORDER WEEKS	28
TOTAL COST (DOLLAR BASE)	$ 4867.70		
TOTAL COST (UNIT COST BASE)	$ 8525.70		

Figure 1. Item Summary Output

RULE PARAMETER

RUN NO 11 PRC DISCRETE SHORTAGE FORMULA C/(CD)**.25 HOLDING RATE 0.50 LAMBDA 1.00

EXPONENTIAL SMOOTHING ALPHA 0.20

TOTAL SYSTEM SUMMARY REPORT

COST OF MATERIAL PROCURED	$ 305058.87
AVERAGE VALUE OF ON HAND STOCK	$ 294010.93
DOLLAR VELOCITY OF ANNUAL DEMAND	$ 230667.64
AVERAGE VALUE OF LEAD TIME STOCK	$ 250416.00
AVERAGE VALUE OF ORDER POINT STOCK	$ 283998.64
ORDER PLACEMENT COST	$ 725.00
TOTAL HOLDING COST	$ 44101.64
TOTAL SHORTAGE COST (DOLLAR BASE)	$ 144.00
TOTAL SHORTAGE COST (UNIT COST BASE)	$ 24833.40
TOTAL COST (DOLLAR BASE)	$ 44970.64
TOTAL COST (UNIT COST BASE)	$ 69660.04
SERVICE PERCENTAGE (AVERAGE)	97.51
AVERAGE BACK ORDER AGE (AVERAGE)	4.6
BACK ORDER SERVICE PERCENTAGE (AVERAGE)	2.49
TOTAL DEMANDS FOR ISSUE	5786
TOTAL DEMANDS FOR FORECAST	7209
TOTAL BACK ORDER WEEKS	656.

Figure 2. System Summary Output

GENERATION OF VARIABLE LEAD TIMES

Initially, lead times for the items being simulated were considered to be generated by sampling from a gamma distribution. To determine which gamma distribution was to be used, information was required on the mean and variance. This information was obtained from SPCC on the specific 24 items to be simulated. Unfortunately all the information could not be used because of errors in the data associated with the calculation of lead time variances. It was previously determined that the standard deviation of lead times for the total items in the system at SPCC varied from 15 to 25 days.

An analysis was made of the existing information (lead times, means and variances), and a decision was made to use the normal distribution in lieu of the gamma distribution. The reasons were:

(a) The mean square to variance ratios were extremely large. This ratio, p, represents one of the two parameters of the gamma distribution. There are no known tables whose range on p varies over the ranges required. The average value of p, obtained from data, was on the order of 150, whereas Pearson's Tables [8] are limited to p = 50.

(b) As p becomes large, the gamma distribution approaches the normal distribution.

To determine the standard deviation, σ_L, of the lead times of the 24 items (it was known that σ_L varied from 15 to 25), a random procedure was used. For each item, a number between 15 and 25 was selected at random; that is, it was assumed that the standard deviations were uniformly distributed over the range 15 to 25. The Random Number Tables in Dixon and Massey [9] were used. Figure 3 shows σ for the 24 items thus generated. The basic information from SPCC provided the mean lead times, μ_L, for each item. To obtain a random sample lead time for a given item, the following method was used. Let $P\{x \leq X\}$ be the probability that the lead time x is less than or equal to a known value X. $P\{x = X\}$ is assumed to be normal, i.e.,

ITEM NO.	FEDERAL STOCK NO.	DESCRIPTION	LEAD TIME (DAYS)	σ_L (DAYS)
1	HF 2010-385-9501	Shim Bearing	330	18
2	HF 2030-318-7319	Pulley Assy. Steering Gear	330	17
3	HF 2040-393-3842	Expander Ring	271	17
4	HF 2805-275-3061	Pin Piston	240	19
5	HF 2805-333-0992	Plug Special Pipe	330	21
6	HF 2815-179-8683	Bracket	600	19
7	HF 2815-343-2678	Bearing Shell Half	290	19
8	HF 2815-354-1217	Plug Retaining Push Rod	330	22
9	HF 2815-364-3753	Cylinder Liner Assy.	330	24
10	HF 2815-391-6903	Gasket	330	19
11	HF 2825-036-3215	Gear Assembly	268	17
12	HF 2825-126-4661	Knife Edge Governor	420	20
13	HF 2825-147-5831	Shaft Assembly Pinion	264	16
14	HF 2825-216-9293	Bearing Assembly	287	19
15	HR 2825-379-3571	Wheel Turbine Bladed	540	24
16	HS 2825-388-1584	Bearing	363	21
17	HS 2825-394-8584	Screw Adjusting	330	20
18	HF 2910-364-2072	Clamp Support	330	19
19	HF 2920-640-7546	Generator Engine Accy.	389	19
20	HF 2930-363-8598	Pump	360	20
21	HS 3110-100-5507	Bearing RLTPR	330	20
22	HF 3610-394-9234	Tire Trolley Wheel	330	22
23	HF 3610-491-2255	Adapter Duplimat Multh.	330	18
24	HF 3950-344-0817	Ring Piston	223	16

Figure 3. Variance of Lead Times

$$P\{x = X\} = \int_{-\infty}^{X} \frac{\exp\{-(x - \mu_L)^2/2\sigma_L^2\}}{\sigma_L\sqrt{2\pi}}\, dx.$$

Setting $X - \mu_L/\sigma_L = y$, then

$$P\{x \leq X\} = P\{\sigma_L y + \mu_L \leq X\} = P\{y \leq X - \mu_L/\sigma_L\},$$

where y is normally distributed with zero mean and unit variance. Hence

$$P\{x \leq X\} = P\{y \leq (X - \mu_L)/\sigma_L\} = \int_{-\infty}^{(x-\mu_L)/\sigma_L} \frac{\exp\{-y^2/2\}}{\sqrt{2\pi}}\, dy.$$

The Random Normal Number Tables in Dixon and Massey [9] were used to determine $(X - \mu_L)/\sigma_L$. Let t_V be a number selected from the table. Then setting

$$t_V = (X - \mu_L)/\sigma_L$$

yields

$$X = t_V\sigma_L + \mu_L,$$

which provides a random sample of a lead time for an item whose distribution is normal with mean μ_L and variance σ_L^2.

The values for the variable lead times for the 24 items are found in Appendix 1.

DATA PREPARATION

Actual demand data and item record information for 200 items were collected from SPCC. The demand information for these items was contained in a file of eighteen thousand transaction cards covering the period from June 1959 to February 1961. These cards contained all stock accounting detail transactions, e.g., receipts, issues, credits, and returns. Other specific inventory information required about each item, such as stock number, nomenclature, unit cost, lead time, weight, cubage, history of demand, and inventory broken into various categories, was contained in the SPCC Consolidated Stock Status Report (CSSR).

The twenty-four items previously selected in IRAD Task 0453 were used as a sample for the purposes of this study. These items were selected to include varying unit costs and varying demands.

Seven types of inventory transactions were selected from the transaction cards for use as input to the simulation. These categories were:

	Type Transaction	Code	Effect Demand Forecast	Effect Inventory Balance
1.	Reportable/Replenishable Demand Issue	A	+	-
2.	Replenishable Demand Issue Credit	B	-	+
3.	Non-Reportable Demand Issue	H		-
4.	Establish Replenishable Demand Obligation	S	+	
5.	Cancel Replenishable Demand Obligation	T	-	
6.	Demand Debit	Y	+	
7.	Demand Credit	Z	-	

A 7090 EDPM Program was written which summarized each type of demand by week, and a demand tape was produced for the 104-week period.

The stock balances of February 1961 obtained from the CSSR were chosen as the initial on hand balances. The stock balances as reported on the CSSRs required adjustment because inventory carried on hand for mobilization reserve and specified planned programs is not considered in establishing the levels of inventory. The ten variable lead times for each of the 24 items was placed on the item record, therefore making the condition on the item record the same for all simulation runs.

PROGRAMMING INVENTORY RULES

Forecasting

The forecasting technique used was simple exponential smoothing which was previously programmed into the simulator under IRAD Task 0453.

Order Point, Order Quantity

Two sets of rules were programmed into the simulator; they were:

(1) PRC's discrete and continuous review rules.

The major portion of these rules were programmed previously under IRAD Task 0453. Modifications were made to these rules, whereby new shortage cost formulas, the Lagragian multiplier, and a new minimum buy routine were added.

(2) SRI's discrete and continuous review rules.

These rules were programmed and added to the simulator.

The following is a mathematical description of the forecasting, order point and order quantity rules.

Forecast of Demand. Simple exponential smoothing with a smoothing constant (a) of 0.2 was used.

The formulas are:

$$F_q = a\,A + (1 - a)\,F'_q$$

$$D = 4\,F_q$$

$$F_{LT} = DL$$

where

F_q = forecast of quarterly demand
F'_q = previously computed F_q
D = forecast of annual demand
F_{LT} = forecast of lead time demand
a = smoothing constant = 0.2
A = actual demand over quarter
L = mean lead time in years.

Standard Deviation of Demand. Simple exponential smoothing with smoothing constant (a) of 0.2 was used in obtaining the mean absolute deviation from which the standard deviation is determined. The formulas are:

$$E = |F'_q - A|$$

$$\overline{MAD} = aE + (1 - a)\,\overline{MAD}'$$

$$\sigma_{F_{LT}} = 1.25\overline{MAD}\sqrt{4L}$$

$$\sigma_D = 2.5(\overline{MAD})$$

where

E = forecast error

$\overline{MAD}$ = mean absolute deviation of quarterly forecast error

$\overline{MAD}'$ = previously computed $\overline{MAD}$

$\sigma_{F_{LT}}$ = standard deviation of demand over lead time

σ_D = standard deviation of annual demand

Shortage Cost Computation. Shortage cost was recomputed every quarter after the forecast had been made. The Shortage Cost formulas used were:

$$S = 50$$

$$S = 50 + \sqrt{C}$$

$$S = C/(CD)^{1/4}$$

where

C = unit cost.

Other inputs were:

P = order cost = \$25

H = annual holding rate

λ = Lagrangian multiplier

σ_L = standard deviation of lead time

PRC Continuous Rule. The continuous review formula for order quantity (Q) is:

$$Q = \text{MAX}[\text{MIN}(\sqrt{2PD/CD}, 5D),\ 6/52\ D]$$

The order point is that value, j = X, for which

$$A(X) \leq HCQ/\lambda SD < A(X-1),$$

where

$$A(i) = 1 - \sum_{i=0}^{j} p(i),$$

and p(i) is the demand probability distribution for the item under consideration. For computational purposes, this distribution is assumed to be one of three types – Poisson, negative binomial, or normal. It is selected according to the size of the forecast of annual demand in the following manner:

Poisson	if	$0 \leq D \leq 2$
Negative Binomial	if	$2 < D \leq 100, \sigma^2_{LT}/F_{LT} > 1$
Normal	if	$2 < D \leq 100, \sigma^2_{LT}/F_{LT} \leq 1$
Normal	if	$100 < D$

The mean for the distribution is F_{LT}, and the standard deviation is $\sigma_{F_{LT}}$.

The formulas describing the above distribution are as follows:

Poisson: $p(0) = e^{-F_{LT}}$

$$p(i) = \frac{F_{LT}}{i} p(i-1), \quad i > 0.$$

Negative Binomial: $p(0) = \frac{1}{qk}$

$$p(i) = \frac{k + (i-1)}{i} \cdot \frac{q-1}{q} \cdot p(i-1),$$

where $q = \sigma^2_{F_{LT}}/F_{LT}$ and $k = F_{LT}/(q-1)$.

Normal: $$p(i) = \frac{\exp\{-(i - F_{LT})^2/2\sigma^2_{F_{LT}}\}}{\sigma_{F_{LT}}\sqrt{2\pi}}$$

The following approximation formulas for computation of the order point were employed in all cases in which the normal distribution was specified:

$$X = F_{LT} + T\,\sigma_{F_{LT}}$$

where

$$T = -644R^3 + 247.7R^2 - 32.26R + 2.713 \quad \text{if } 0.01 \leq R < 0.14,$$

$$T = 1.59R^2 - 3.893R + 1.553 \quad \text{if } 0.14 \leq R < .50, \text{ and}$$

$$R = HCQ/\lambda SD.$$

PRC Discrete Rule. The order quantity and order point computations are the same as in the PRC continuous rules described above with the exception that the forecast is given by:

$$F_{LT} = D\,(L + 1/8).$$

SRI Continuous Rule. The continuous review formulas for order quantity (Q) and order point (X) are shown below:

$$Q^* = FD + Q_w \text{ if } Q_w^2 \geq 2.25\,F^2\,D^2$$

$$Q^* = 1.85\,(F\,DQ_w^2)^{1/3} \text{ otherwise}$$

$$Q = MIN\{MAX[Q^*,\ 1 + (DV_D)/2,\ 6/52\ D]\ ,\ 5D\}$$

$$X^* = F\,D\,\ln\frac{K\,(1 - e^{-Q/FD})}{QP_o} + \frac{D}{2}\,(W + V_D)$$

$$X = MAX\,[1,\ DL,\ X^*],$$

where

W = review interval = 0

$Q_W = \sqrt{2PD/CH}$

$V_D = (\sigma_D/D)^2$

$V_L = (\sigma_L/L)^2$

$$k = \sqrt{\frac{(1 + V_L)\,(1 + 2\,V_L + 3V_D/L) + (V_D/L)^2}{3(1 + V_L + V_D/L)}}$$

$$K = \frac{F_{LT}}{2k}\,(1 + V_L + V_D/L)$$

$$F = kL$$

$$P_0 = \frac{HCF}{HCF + \lambda S}\ .$$

SRI Discrete Rule. The discrete review formulas for order quantity (Q) and order point (X) are shown below:

$$Q = \text{MIN}\{\text{MAX}[Q^* + D/2\,(W + V_D),\ 1 + (DV_D)/2 + DW/2,\ 6/52D],\ 5\ D\}$$

$$X = \text{MAX}[X^*,\ 1,\ D\,(L + 1/8)].$$

where

W = review interval in years = 0.25.

MATCHING

After the modifications and additions were made to the simulator, twelve simulation runs were made with PRC inventory rules. For each combination of the rules, the simulation was run for 104 weeks of demand history with twenty-four items having variable lead times.

Six runs utilized continuous review, with the available inventory level being checked for reorder every two weeks. In the other six runs a discrete review was made. In this case the available inventory level was checked for reorder every thirteen weeks.

Each set of the six rule combinations involved using two values of holding rate in the order quantity and order point formulas (10 percent and 50 percent), and three values of the shortage cost in the order point formula, namely:

$$\$50,\ \$50 + \sqrt{\text{Unit Cost}},\ \frac{\text{Unit Cost}}{[(\text{Unit Cost})\,(\text{Annual Demand})]^{0.25}}$$

In all simulation runs, the forecasting technique used was simple exponential smoothing with the value of the smoothing constant being 0.2. The value of the Lagrangian multiplier (λ) for all PRC's rules was held at 1.0.

The resulting inventory levels and costs for these twelve rule combinations were obtained from the output of the total system summary. The value of the cost of material procured, the average value of on-hand stock, and the system effectiveness for the twelve PRC rule combinations are shown in Figure 4.

The values of the cost of material procured and average value of the on-hand stock for the twelve PRC rules, were used as the basis for obtaining corresponding results with the SRI rules. The requirement was to vary the SRI rules so that the average value of the on-hand stock and cost of material procured were within a given tolerance of that obtained using PRC rules. This was accomplished by varying the Lagrangian multiplier and holding cost in the SRI rules so that the average value of the on-hand stock was within plus or minus 2 percent, and the cost of material procured was within plus or minus 5 percent of that obtained by utilizing PRC rules.

Initially several exploratory runs were made with the SRI rules to evaluate the effect of using various holding rates and Lagrangian multipliers (H and λ respectively). The results of those runs were used as the basis for determining more specifically what values of λ and H would be used for obtaining the required match.

The value of the cost of material procured, the average value of on-hand stock, and the system effectiveness obtained for the successive runs of using SRI rules are shown on the following six figures (Figure 5 through 10).

Six graphical plots, Figures 11 through 16, were produced from the results of using PRC rules (Figure 4) and SRI rules (Figure 5 through 10)—three plots for the discrete review, one associated with each shortage cost and three plots of the continuous review, again with one shortage cost associated with each.

On each of the six plots, two areas (corresponding to the two holding rates used) were drawn representing $\pm$ 2 percent of the average value of on-hand stock and $\pm$ 5 percent of the cost of material procured, obtained from using the PRC rules.

Points were plotted for the various SRI runs having the same shortage cost and review period as the corresponding PRC rules. Curves were then drawn through the points having the same holding rates.

Run No.	Type Review	Shortage Cost	Value of λ	Value of Holding Rate	Cost of Material Procured	Average Value of On Hand Stock	Service Percentage	Total Back Order Weeks	Average Back Order Age (in weeks)	Total Items In Back Order
3	Continuous	$50	1.00	10%	$355,708.50	$302,223.62	99.72	140	8.7	16
1	"	$50+√Unit Cost	1.00	10%	371,539.87	303,113.25	99.74	132	8.8	15
2	"	$\frac{\text{Unit Cost}}{[(\text{Unit Cost})(\text{Annual Demand})]^{\frac{1}{m}}}$	1.00	10%	324,692.73	296,760.91	99.67	165	8.7	
6	"	$50	1.00	50%	313,353.02	296,345.29	99.57	265	10.6	25
4	"	$50+√Unit Cost	1.00	50%	320,265.92	297,402.89	99.59	244	10.2	24
5	"	$\frac{\text{Unit Cost}}{[(\text{Unit Cost})(\text{Annual Demand})]^{\frac{1}{m}}}$	1.00	50%	274,450.37	292,913.71	98.41	451	4.9	92
9	Discrete	$50	1.00	10%	365,472.58	304,600.26	99.78	105	8.1	13
7	"	$50+√Unit Cost	1.00	10%	380,960.58	305,280.71	99.79	98	8.2	12
8	"	$\frac{\text{Unit Cost}}{[(\text{Unit Cost})(\text{Annual Demand})]^{\frac{1}{m}}}$	1.00	10%	350,566.29	300,290.30	99.67	148	7.8	19
12	"	$50	1.00	50%	322,676.49	300,171.72	99.60	202	8.8	2
10	"	$50+√Unit Cost	1.00	50%	328,633.86	300,872.09	99.62	182	8.3	22
11	"	$\frac{\text{Unit Cost}}{[(\text{Unit Cost})(\text{Annual Demand})]^{\frac{1}{m}}}$	1.00	50%	302,973.51	293,922.24	97.51	656	4.6	144

Figure 4. System Summary Results, PRC Rules

Run No.	Type Review	Shortage Cost	Value of λ	Value of Holding Rate	Cost of Material Procured	Average Value of On Hand Stock	Service Percentage	Total Back Order Weeks	Average Back Order Age (in weeks)	Total Items In Back Order
234	Continuous	$50	0.50	10%	$278,029.37	$297,617.16	98.76	198	2.7	72
235	"	"	1.00	10%	322,481.09	307,097.55	99.93	44	11.0	4
236	"	"	1.50	10%	362,129.64	323,264.12	99.97	28	14.0	2
237	"	"	2.00	10%	393,273.62	335,017.27	99.97	28	14.0	2
238	"	"	2.50	10%	418,623.94	344,690.97	99.97	28	14.0	2
239	"	"	3.00	10%	441,134.26	355,939.38	99.97	28	14.0	2
240	"	"	4.00	10%	474,362.95	373,829.59	99.97	28	14.0	2
241	"	"	1.00	30%	294,076.61	296,018.66	98.51	310	3.6	86
242	"	"	2.00	30%	313,569.61	298,845.85	99.78	116	8.9	13
168	"	"	3.00	30%	346,336.44	304,905.60	99.86	76	9.5	8
169	"	"	4.00	30%	385,562.32	316,552.06	99.91	52	10.4	5
170	"	"	5.00	30%	410,113.26	327,398.27	99.97	28	14.0	2
243	"	"	1.00	40%	298,981.23	295,847.07	98.48	326	3.7	88
244	"	"	2.00	40%	300,946.25	296,616.99	98.69	214	2.8	76
171	"	"	3.00	40%	329,563.36	299,864.84	99.78	116	8.9	13
109	"	"	4.00	40%	353,165.15	303,719.29	99.84	84	9.3	9
110	"	"	4.50	40%	364,286.55	309,638.87	99.86	76	9.5	8
172	"	"	5.00	40%	375,330.61	313,705.15	99.88	68	9.7	7
245	"	"	6.00	40%	395,228.29	321,742.50	99.93	44	11.0	4
173	Continuous	$50	3.00	100%	$286,506.92	$294,649.95	98.41	361	3.9	92
174	"	"	4.00	100%	287,804.77	295,072.34	98.62	253	3.2	80
175	"	"	5.00	100%	288,472.05	295,380.34	98.63	242	3.1	79
111	"	"	6.00	100%	301,402.01	296,419.76	99.69	156	8.7	18
246	"	"	8.00	100%	324,198.69	299,633.66	99.76	124	8.9	14
247	"	"	10.00	100%	343,433.45	303,202.77	99.79	108	9.0	12
248	"	"	12.00	100%	362,375.12	312,541.02	99.83	92	9.2	10
249	"	"	15.00	100%	386,269.09	321,258.90	99.88	68	9.7	7
112	"	"	7.00	110%	305,589.63	286,734.58	99.71	148	8.7	17

Figure 5. System Summary Results, SRI Rules (Continuous $50)

Run No.	Type Review	Shortage Cost	Value of λ	Value of Holding Rate	Cost of Material Procured	Average Value of On Hand Stock	Service Percentage	Total Back Order Weeks	Average Back Order Age (in weeks)	Total Items in Back Order
42	Continuous	50+√Unit Cost	0.50	10%	$285,492.83	$296,027.67	98.60	270	3.3	81
43	"	"	1.00	10%	343,267.78	316,630.96	99.97	28	14	2
44	"	"	2.00	10%	422,757.29	345,093.44	99.97	28	14	2
45	"	"	3.00	10%	473,385.35	373,602.41	99.97	28	14	2
46	"	"	4.00	10%	506,918.59	389,986.91	99.97	28	14	2
47	"	"	5.00	10%	542,864.35	404,146.34	99.97	28	14	2
36	"	"	0.50	15%	282,764.67	296,727.59	98.57	352	4.2	83
37	"	"	1.00	15%	324,777.46	302,796.00	99.86	76	9.5	8
38	"	"	2.00	15%	395,777.51	326,744.14	99.97	28	14	2
39	"	"	3.00	15%	424,862.19	342,249.57	99.76	28	14	14
40	"	"	4.00	15%	478,726.02	364,989.80	99.97	28	14	2
41	"	"	5.00	15%	504,951.21	377,894.59	99.97	28	14	2
30	"	"	0.50	20%	283,682.39	296,134.19	98.53	380	4.5	85
31	"	"	1.00	20%	299,183.84	297,534.93	98.76	182	2.5	72
32	"	"	2.00	20%	389,759.75	314,735.14	99.91	52	10.4	5
33	"	"	3.00	20%	403,784.45	330,724.64	99.97	28	14.0	2
34	"	"	4.00	20%	436,227.82	343,426.69	99.97	28	14.0	2
35	"	"	5.00	20%	462,062.34	360,935.58	99.97	28	14.0	2
24	Continuous	50+√Unit Cost	0.50	25%	$273,443.39	$296,152.38	98.51	310	3.6	86
25	"	"	1.00	25%	275,197.71	296,439.24	98.51	310	3.6	86
26	"	"	2.00	25%	326,334.49	306,022.61	99.86	76	9.5	8
27	"	"	3.00	25%	364,723.38	321,220.75	99.95	36	12.0	3
28	"	"	4.00	25%	399,311.66	333,689.50	99.97	28	14.0	2
29	"	"	5.00	25%	424,060.08	343,836.01	99.97	28	14.0	2
15	"	"	0.05	30%	291,263.34	294,737.83	98.50	318	3.7	87
13	"	"	0.50	30%	293,334.57	296,724.80	98.50	318	3.7	87
16	"	"	1.00	30%	294,059.68	296,093.56	98.50	318	3.7	87
17	"	"	2.00	30%	331,240.99	302,002.44	99.81	100	9.1	11
270	"	"	2.60	30%	354,284.12	307,130.86	99.86	76	9.5	8
48	"	"	3.00	30%	379,373.90	314,217.45	99.90	60	10.0	6
18	"	"	4.00	30%	410,731.31	327,853.30	99.97	28	14.0	2
19	"	"	8.00	30%	488,116.93	367,348.60	99.97	28	14.0	2
100	"	"	4.00	40%	376,379.61	314,119.75	99.88	68	9.7	7

Figure 6. System Summary Results, SRI Rules (Continuous $50 + √Unit Cost) (Sheet 1)

Run No.	Type Review	Shortage Cost	Value of λ	Value of Holding Rate	Cost of Material Procured	Average Value of On Hand Stock	Service Percentage	Total Back Order Weeks	Average Back Order Age (in weeks)	Total Items in Back Order
101	"	"	4.50	40%	288,996.91	319,569.75	99.90	60	10.0	6
52	"	"	2.00	50%	288,851.59	296,822.90	98.67	222	2.9	975
53	"	"	3.00	50%	318,389.72	299,063.00	99.76	124	8.9	14
54	"	"	4.00	50%	342,634.12	303,516.26	99.81	100	9.1	11
55	"	"	5.00	50%	371,742.63	314,568.50	99.86	76	9.5	8
56	"	"	6.00	50%	382,168.24	321,450.42	99.90	60	10.0	6
57	"	"	4.00	75%	310,852.71	297,174.24	99.71	148	6.7	17
58	"	"	5.00	75%	328,634.52	299,856.51	99.76	124	8.9	14
59	"	"	6.00	75%	338,615.16	303,763.77	99.79	108	9.0	12
60	"	"	7.00	75%	354,461.34	311,810.61	99.83	92	9.2	10
61	Continuous	50+√Unit Cost	8.00	75%	$368,271.09	$316,926.70	99.86	72	9.5	8
14	"	"	0.50	100%	285,140.04	293,861.73	96.39	370	4.0	93
20	"	"	1.00	100%	285,343.59	294,143.21	96.39	370	4.0	93
21	"	"	2.00	100%	286,092.47	294,471.36	96.39	370	4.0	93
22	"	"	4.00	100%	288,139.60	295,274.06	96.63	242	3.1	79
102	"	"	6.00	100%	318,896.10	296,419.80	99.72	140	8.7	16
62	"	"	6.00	100%	318,896.10	296,419.80	99.72	140	8.7	16
63	"	"	7.00	100%	331,460.73	300,118.76	99.76	124	8.9	14
23	"	"	8.00	100%	343,991.14	303,750.19	99.79	108	9.0	12
64	"	"	9.00	100%	356,348.61	310,448.23	99.81	100	9.1	11
65	"	"	10.00	100%	367,633.73	314,504.16	99.83	92	9.2	10
66	"	"	11.00	100%	377,765.05	318,184.32	99.86	76	9.5	8
103	"	"	7.00	110%	323,169.32	299,380.38	99.74	132	8.8	15
67	"	"	9.00	150%	315,628.76	296,342.20	99.72	140	8.7	16
68	"	"	12.00	150%	341,121.07	303,763.21	99.78	116	8.9	13
69	"	"	15.00	150%	364,521.28	314,214.86	99.83	92	9.2	10
70	"	"	18.00	150%	384,145.81	321,346.62	99.86	76	9.5	8
71	"	"	21.00	150%	401,729.98	330,506.86	99.90	60	10.0	6

Figure 6. System Summary Results, SRI Rules (Continuous $50 + √Unit Cost) (Sheet 2)

Run No.	Type Review	Shortage Cost	Value of λ	Value of Holding Rate	Cost of Material Procured	Average Value of On Hand Stock	Service Percentage	Total Back Order Weeks	Average Back Order Age (in weeks)	Total Items In Back Order
197	Continuous	$\frac{\text{Unit Cost}}{[(\text{Unit Cost})(\text{Annual Demand})]^{.25}}$	0.50	10%	$274,206.68	$296,868.34	98.76	196	2.7	72
198	"	"	1.00	10%	274,206.68	296,868.34	98.76	196	2.7	72
199	"	"	2.00	10%	274,862.06	296,935.42	98.76	196	2.7	72
200	"	"	3.00	10%	276,822.02	297,140.48	98.86	126	1.9	65
201	"	"	4.00	10%	290,979.31	300,745.96	98.93	102	1.6	62
202	"	"	8.00	10%	400,542.68	327,236.79	99.97	28	14.0	2
203	"	"	16.00	10%	507,826.18	350,722.45	99.97	28	14.0	2
204	"	"	1.00	30%	290,727.68	294,540.66	98.51	310	3.6	86
197	"	"	5.00	30%	290,866.46	294,710.23	98.51	310	3.6	86
198	"	"	6.00	30%	291,861.64	295,362.34	98.72	196	2.7	74
150	"	"	7.00	30%	292,279.64	295,567.12	98.74	190	2.6	73
160	"	"	8.00	30%	293,065.29	295,862.04	98.77	174	2.5	71
206	"	"	12.00	30%	230,858.44	302,618.04	99.86	68	9.7	7
206	"	"	16.00	30%	367,641.00	309,843.22	99.93	44	11.0	4
207	"	"	24.00	30%	427,883.25	325,535.61	99.97	28	14.0	2
208	"	"	32.00	30%	460,946.50	340,297.96	99.97	28	14.0	2
209	"	"	0.50	40%	296,932.09	294,482.71	98.48	326	3.7	86
104	"	"	4.00	40%	296,932.09	294,482.71	98.48	326	3.7	86
105	"	"	4.50	40%	296,932.09	294,482.71	98.48	326	3.7	86
161	"	"	5.00	40%	296,938.96	294,482.71	98.48	326	3.7	86
162	"	"	6.00	40%	296,986.89	294,603.32	98.48	326	3.7	86
163	"	"	7.00	40%	296,814.59	294,991.00	98.69	214	2.8	76
164	"	"	8.00	40%	297,867.45	295,209.84	98.69	214	2.8	76
210	"	"	12.00	40%	299,899.35	295,899.79	98.77	174	2.5	71
211	"	"	16.00	40%	320,650.62	301,917.62	99.86	76	9.5	8
212	Continuous	$\frac{\text{Unit Cost}}{[(\text{Unit Cost})(\text{Annual Demand})]^{.25}}$	32.00	40%	$423,427.49	$325,130.85	99.97	28	14.0	2
213	"	"	64.00	40%	530,853.90	362,060.12	99.97	28	14.0	2
214	"	"	0.50	100%	282,840.84	293,253.54	98.39	370	4.0	93
165	"	"	5.00	100%	282,840.84	293,253.54	98.39	370	4.0	93
166	"	"	6.00	100%	282,840.84	293,253.54	98.39	370	4.0	93
166	"	"	7.00	100%	282,854.64	293,253.54	98.39	370	4.0	93
167	"	"	8.00	100%	282,861.54	293,253.54	98.39	370	4.0	93
215	"	"	32.00	100%	294,053.58	297,670.09	98.76	162	2.5	72
216	"	"	64.00	100%	304,118.36	314,106.97	99.91	52	10.4	5
217	"	"	128.00	100%	486,086.30	349,104.04	99.97	28	14.0	2
218	"	"	256.00	100%	586,830.11	380,600.01	99.97	28	14.0	2
167	"	"	7.00	116%	283,019.17	293,066.76	98.39	194	2.7	93

Figure 7. System Summary Results, SRI Rules (Continuous)
$\{(\text{Unit Cost})/[(\text{Unit Cost})\ (\text{Annual Demand})]^{.25}\}$

Run No.	Type Review	Shortage Cost	Value of λ	Value of Holding Rate	Cost of Material Procured	Average Value of On Hand Stock	Service Percentage	Total Back Order Weeks	Average Back Order Age (in weeks)	Total Items In Back Order
219	Discrete	$50	0.50	10%	$373,251.60	$300,124.74	97.65	620	4.6	136
220	"	"	1.00	10%	406,074.79	309,736.06	99.95	35	11.7	3
221	"	"	1.50	10%	445,540.34	329,860.79	99.97	28	14.0	2
222	"	"	2.00	10%	476,973.74	341,856.79	99.97	28	14.0	2
223	"	"	2.50	10%	502,668.86	351,388.78	99.97	28	14.0	2
224	"	"	3.00	10%	523,751.59	359,351.36	99.97	28	14.0	2
225	"	"	4.00	10%	557,487.60	373,352.62	99.97	28	14.0	2
226	"	"	0.50	30%	349,476.30	299,346.54	97.65	620	4.6	136
227	"	"	1.00	30%	350,240.50	299,698.77	97.65	620	4.6	136
228	"	"	2.00	30%	358,213.02	300,355.84	97.70	573	4.3	133
146	"	"	2.50	30%	375,731.18	306,735.61	99.84	77	8.6	9
147	"	"	3.00	30%	390,864.36	306,870.63	99.88	63	9.0	7
148	"	"	4.00	30%	417,405.87	319,846.09	99.93	42	10.5	4
149	"	"	5.00	30%	441,566.79	335,475.83	99.97	28	14.0	2
229	"	"	1.00	40%	343,907.46	299,104.34	97.65	620	4.6	136
230	"	"	2.00	40%	346,158.73	299,470.55	97.65	620	4.6	136
150	"	"	2.50	40%	348,329.76	299,796.09	97.68	580	4.3	134
151	"	"	3.00	40%	362,515.30	304,932.79	99.81	91	8.3	11
152	"	"	5.00	40%	406,011.92	317,470.30	99.91	49	9.8	5
121	"	"	4.00	40%	385,971.39	308,256.51	99.86	70	8.7	8
122	"	"	4.50	40%	396,184.51	309,637.70	99.88	63	9.0	7
153	"	"	2.50	100%	332,205.22	297,897.46	97.65	620	4.6	136
154	"	"	3.00	100%	332,413.22	297,967.06	97.65	620	4.6	136
155	"	"	4.00	100%	332,815.13	298,112.96	97.65	620	4.6	136
156	"	"	5.00	100%	334,272.38	298,442.97	97.61	608	4.4	138
123	"	"	6.00	100%	336,308.29	298,636.00	97.65	594	4.4	136
231	"	"	9.00	100%	368,383.55	308,064.79	99.81	91	8.3	11
232	"	"	12.00	100%	389,923.09	314,716.41	99.86	70	8.7	8
233	"	"	15.00	100%	418,648.49	328,561.12	99.91	49	9.8	5
124	"	"	7.00	110%	337,974.45	298,639.78	97.65	594	4.4	136

Figure 8. System Summary Results, SRI Rules (Discrete $50)

Run No.	Type Review	Shortage Cost	Value of λ	Value of Holding Rate	Cost of Material Procured	Average Value of On Hand Stock	Service Percentage	Total Back Order Weeks	Average Back Order Age (in weeks)	Total Items In Back Order
250	Discrete	$50 + $\sqrt{\text{Unit Cost}}$	0.50	10%	$373491.42	$300200.15	97.65	620	4.6	136
251	"	"	1.00	10%	$426876.67	$319186.55	99.97	28	14.0	2
252	"	"	1.50	10%	$470447.46	$339489.62	99.97	28	14.0	2
253	"	"	2.00	10%	$503514.14	$351708.25	99.97	28	14.0	2
254	"	"	2.50	10%	$529771.03	$361160.70	99.97	28	14.0	2
255	"	"	3.00	10%	$551426.88	$370650.46	99.97	28	14.0	2
256	"	"	4.00	10%	$591334.90	$386420.81	99.97	28	14.0	2
257	"	"	0.50	30%	$349512.89	$298355.93	97.65	620	4.6	136
258	"	"	1.00	30%	$350276.95	$298709.53	97.65	620	4.6	136
125	"	"	2.00	30%	$375737.84	$306680.57	99.83	84	8.4	10
126	"	"	2.50	30%	$394212.57	$309276.29	99.88	63	9.0	7
51	"	"	3.00	30%	$411815.81	$318231.42	99.91	49	9.8	5
127	"	"	4.00	30%	$442613.56	$335833.86	99.97	28	14.	2
128	"	"	5.00	30%	$467890.41	$341909.41	99.97	28	14.	2
50	"	"	3.00	35%	$393326.54	$306283.48	99.88	63	9	7
259	"	"	0.50	40%	$343185.46	$298777.55	97.65	620	4.6	136
260	"	"	1.00	40%	$343943.81	$299114.58	97.65	620	4.6	136
129	"	"	2.00	40%	$348264.29	$299694.84	97.68	580	4.3	134
130	"	"	2.50	40%	$365539.73	$305340.43	99.81	91	8.3	11
131	"	"	3.00	40%	$380654.60	$307451.72	99.84	77	8.6	9
113	"	"	4.00	40%	$407563.90	$317661.80	99.90	56	9.3	6
114	"	"	4.50	40%	$419536.87	$328178.80	99.91	49	9.8	5
132	"	"	5.00	40%	$431210.45	$332431.16	99.95	35	11.7	3
133	"	"	2.00	100%	$331964.71	$297820.27	97.65	620	4.6	136
134	"	"	2.50	100%	$332241.57	$297907.70	97.65	620	4.6	136
135	"	"	3.00	100%	$332449.64	$297960.13	97.65	620	4.6	136
136	"	"	4.00	100%	$334020.58	$298341.79	97.81	608	4.4	136
137	"	"	5.00	100%	$339169.74	$298612.86	97.65	594	4.4	136
138	"	"	6.00	100%	$353495.95	$305925.70	99.78	105	8.1	13
262	"	"	7.00	100%	$366162.57	$307649.39	99.79	96	8.2	12
263	"	"	8.00	100%	$377370.77	$309226.20	99.83	84	8.4	10
264	"	"	9.00	100%	$388602.27	$313146.05	99.84	77	8.6	9
265	"	"	10.00	100%	$396936.78	$316147.45	99.86	70	8.7	8
116	"	"	7.00	100%	$355476.64	$306439.12	99.78	105	8.1	13

Figure 9. System Summary Results, SRI Rules (Discrete $50 + $\sqrt{\text{Unit Cost}}$)

Run No.	Type Review	Shortage Cost	Value of λ	Value of Holding Rate	Cost of Material Procured	Average Value of On Hand Stock	Service Percentage	Total Back Order Weeks	Average Back Order Age (in weeks)	Total Items In Back Order
176	Discrete	Unit Cost / [(Unit Cost)(Annual Demand)]$^{.25}$	0.50	30%	$347753.74	$296233.61	97.65	620	4.6	136
138	"	"	3.00	30%	$347753.74	$296233.61	97.65	620	4.6	136
139	"	"	4.00	30%	$347753.74	$296233.61	97.65	620	4.6	136
140	"	"	5.00	30%	$347774.44	$296236.53	97.65	620	4.6	136
177	"	"	12.00	30%	$358250.87	$299986.71	97.81	531	4.2	127
178	"	"	16.00	30%	$396244.57	$311182.17	99.95	35	11.7	3
179	"	"	24.00	30%	$452078.25	$327469.95	99.97	28	14.0	2
180	"	"	32.00	30%	$494883.97	$346062.31	99.97	28	14.0	2
181	"	"	0.50	40%	$341775.95	$297756.19	97.65	620	4.6	136
141	"	"	3.00	40%	$341775.95	$297756.19	97.65	620	4.6	136
117	"	"	4.00	40%	$341775.95	$297756.19	97.65	620	4.6	136
118	"	"	4.50	40%	$341775.95	$297756.19	97.65	620	4.6	136
142	"	"	5.00	40%	$341775.95	$297756.19	97.65	620	4.6	136
182	"	"	12.00	40%	$344776.86	$298419.14	97.75	552	4.2	130
183	"	"	16.00	40%	$353335.86	$299898.64	97.81	531	4.2	127
184	"	"	32.00	40%	$450881.28	$326877.00	99.97	28	14.0	2.0
185	"	"	64.00	40%	$554296.91	$363524.24	99.97	28	14.0	2.0
186	"	"	0.50	100%	$329072.39	$296685.27	97.65	620	4.6	136
143	"	"	3.00	100%	$329072.39	$296685.27	97.65	620	4.6	136
144	"	"	4.00	100%	$329072.39	$296685.27	97.65	620	4.6	136
145	"	"	5.00	100%	$329072.39	$296685.27	97.65	620	4.6	136
119	"	"	6.00	100%	$329072.39	$296685.27	97.69	620	4.6	136
187	"	"	16.00	100%	$329165.04	$296745.67	97.65	620	4.6	136
188	"	"	32.00	100%	$333862.16	$297520.55	97.72	566	4.3	132
189	"	"	64.00	100%	$412795.10	$316760.90	99.95	35	11.7	3
190	"	"	128.00	100%	$513289.31	$351247.09	99.97	28	14.0	2
120	"	"	7.00	110%	$326081.52	$296582.09	97.65	620	4.6	136
191	"	"	0.50	300%	$316426.12	$295618.68	97.56	630	4.5	141
192	"	"	16.00	300%	$316426.12	$295618.68	97.56	630	4.5	141
193	"	"	32.00	300%	$316446.82	$295624.32	97.60	626	4.5	139
194	"	"	64.00	300%	$319123.02	$296197.71	97.81	608	4.4	138
195	"	"	128.00	300%	$351866.25	$306666.04	99.83	84	8.4	10
196	"	"	256.00	300%	$447282.05	$331461.70	99.97	28	14.0	2

Figure 10. System Summary Results, SRI Rules (Discrete)
$\{(\text{Unit Cost})/[(\text{Unit Cost})(\text{Annual Demand})]^{.25}\}$

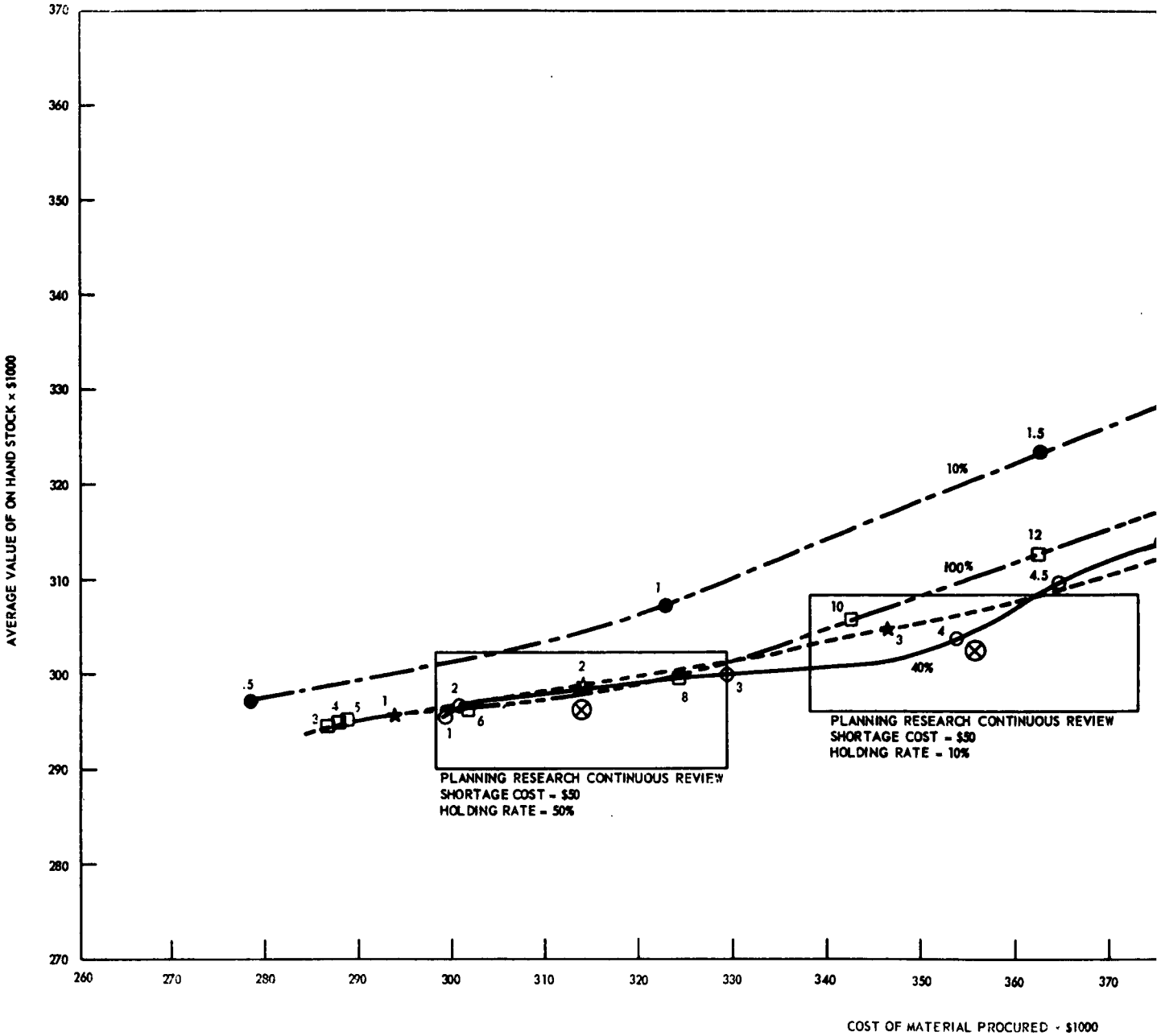
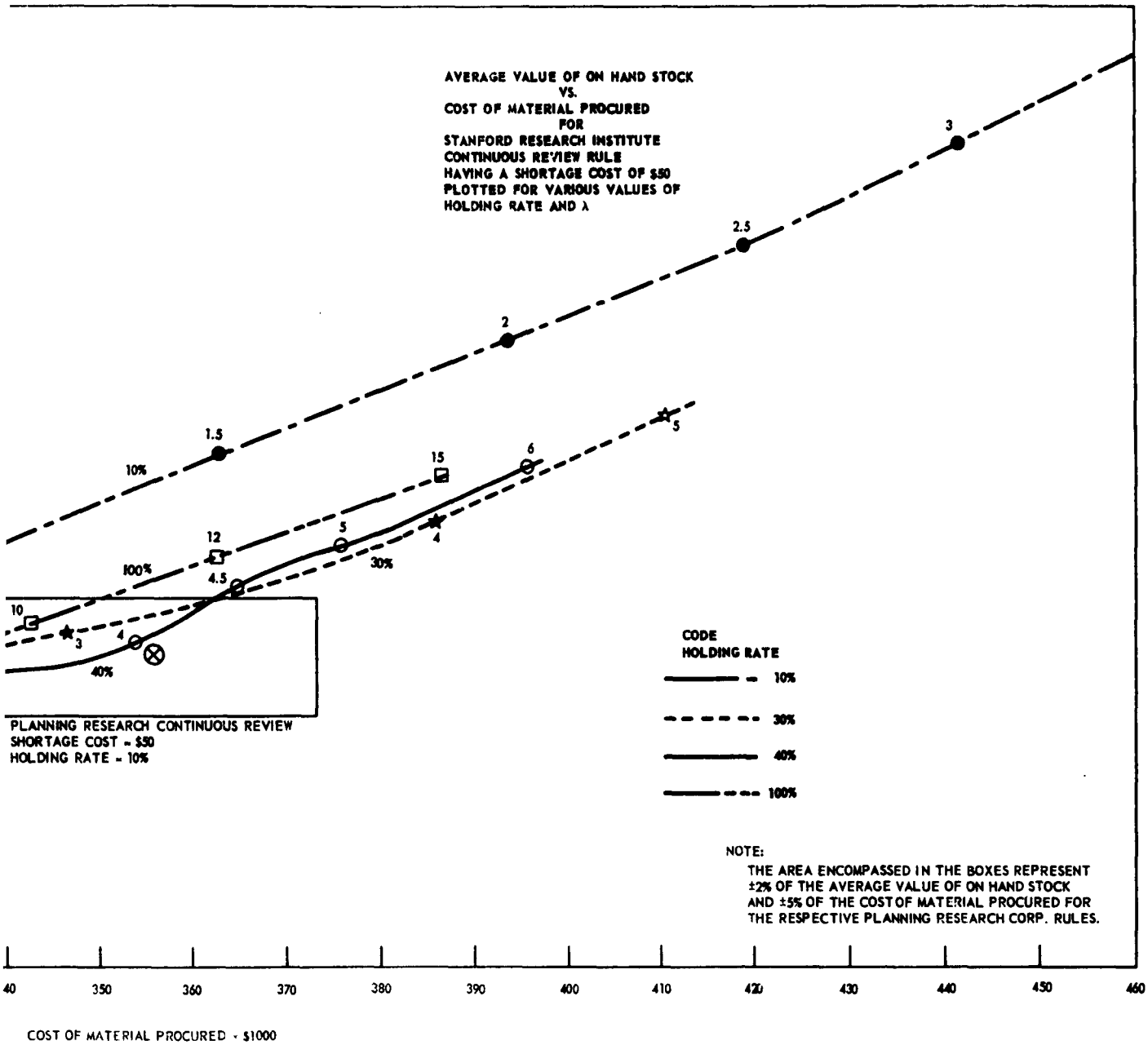


Figure 11. Average Inventory vs Material Procured, SRI Rule



y vs Material Procured, SRI Rules (Continuous $50)

2

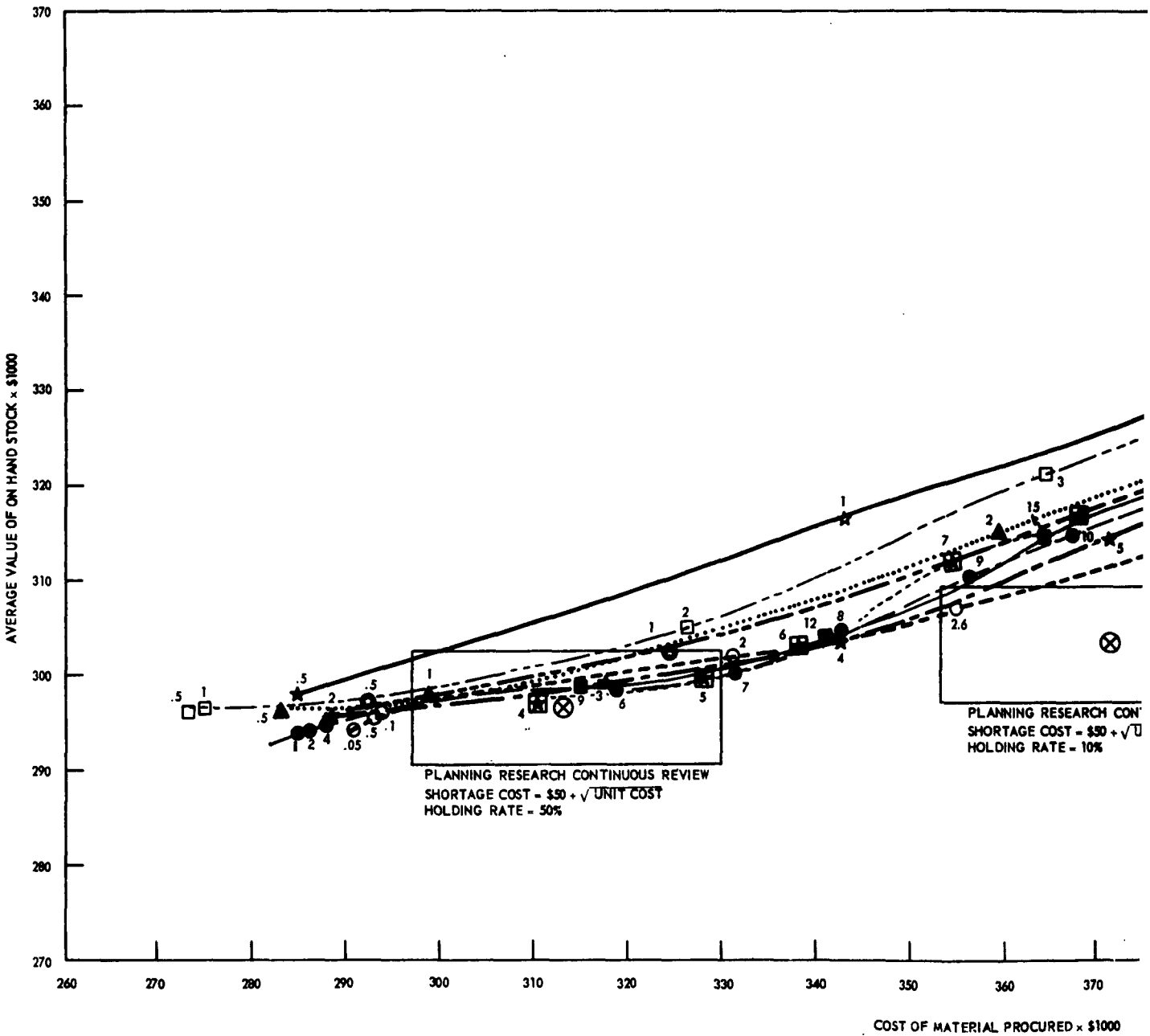
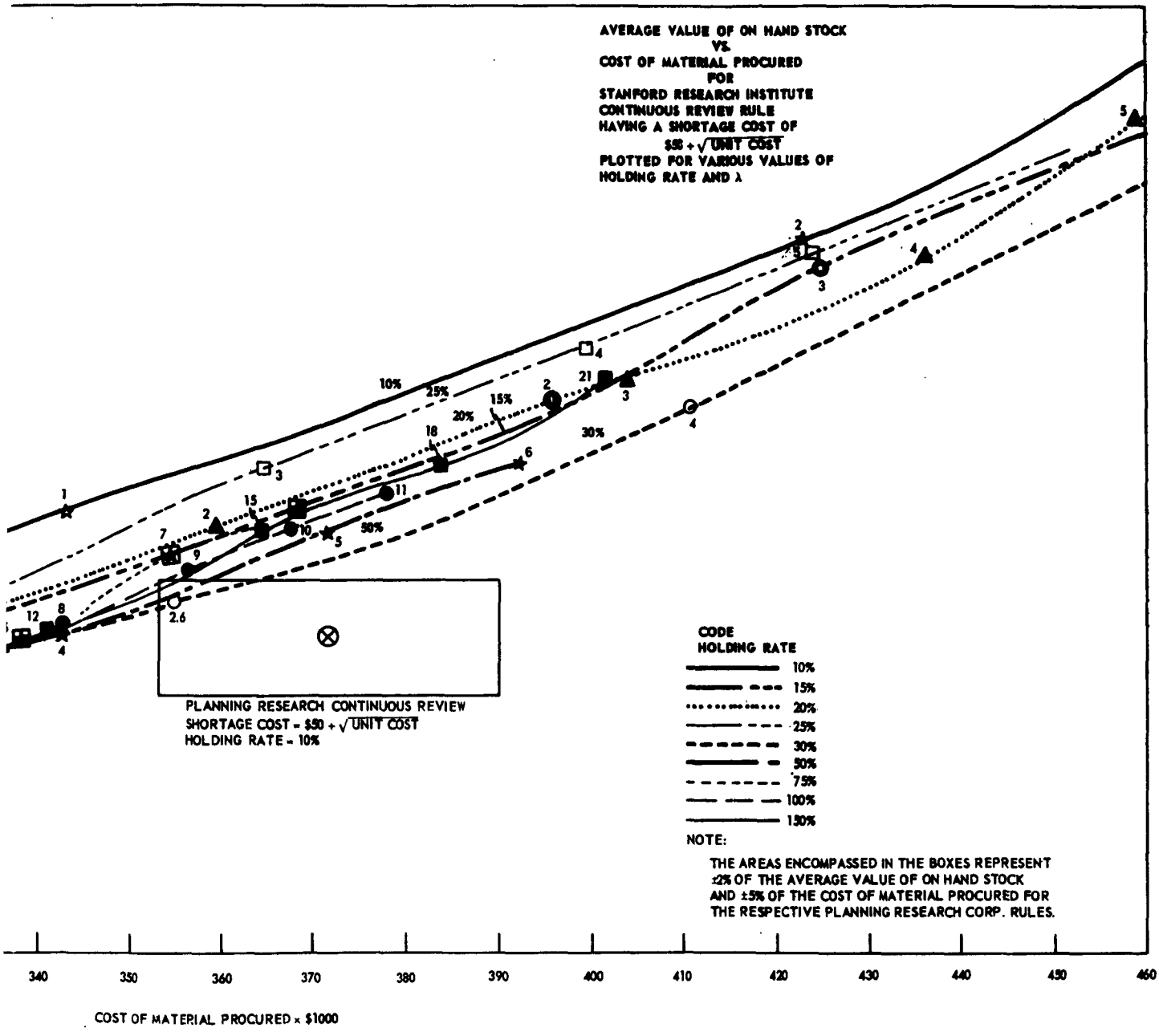


Figure 12. Average Inventory vs Material Procured, SRI Rules (



y vs Material Procured, SRI Rules (Continuous \$50 + $\sqrt{\text{Unit Cost}}$)

2

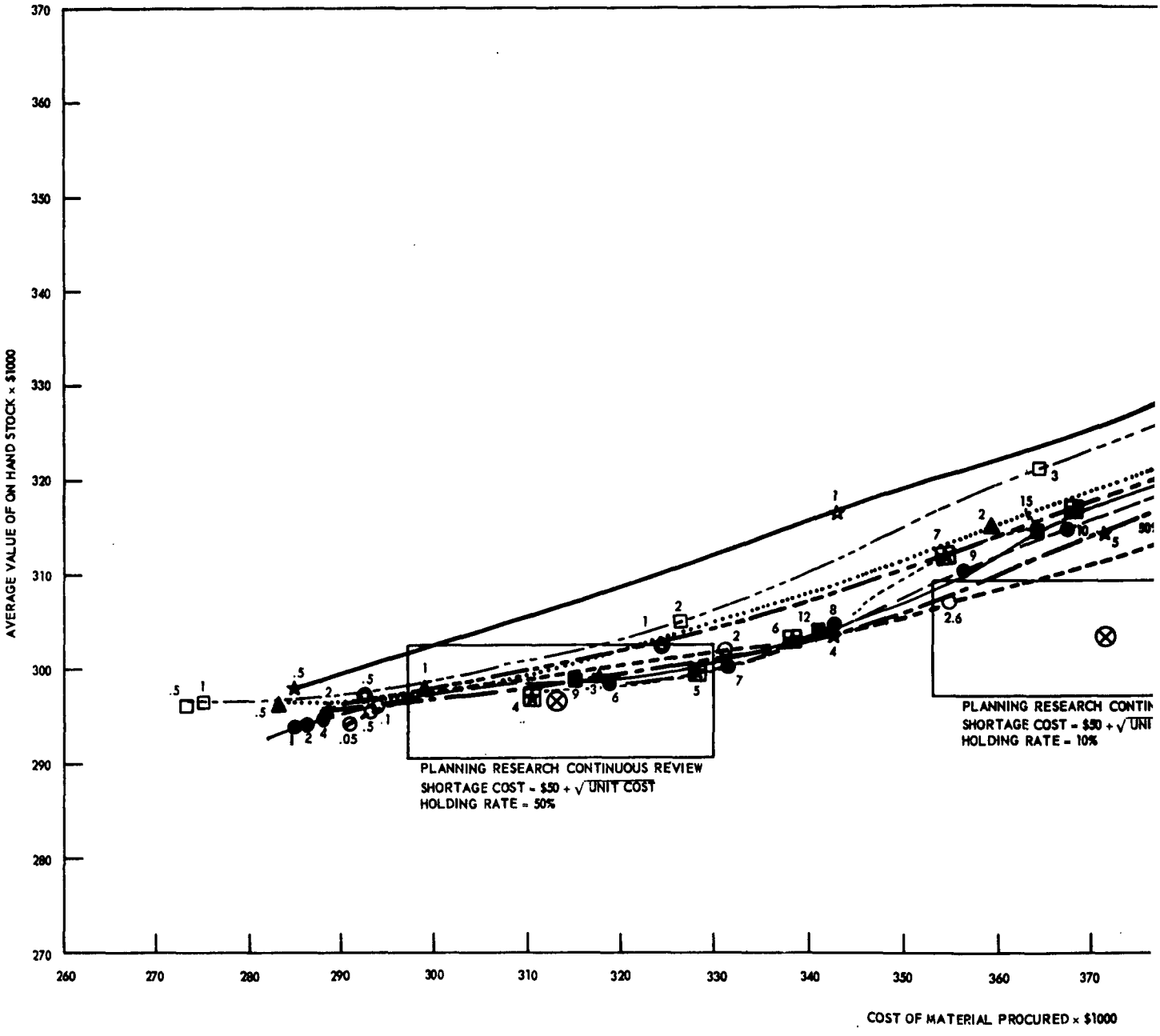
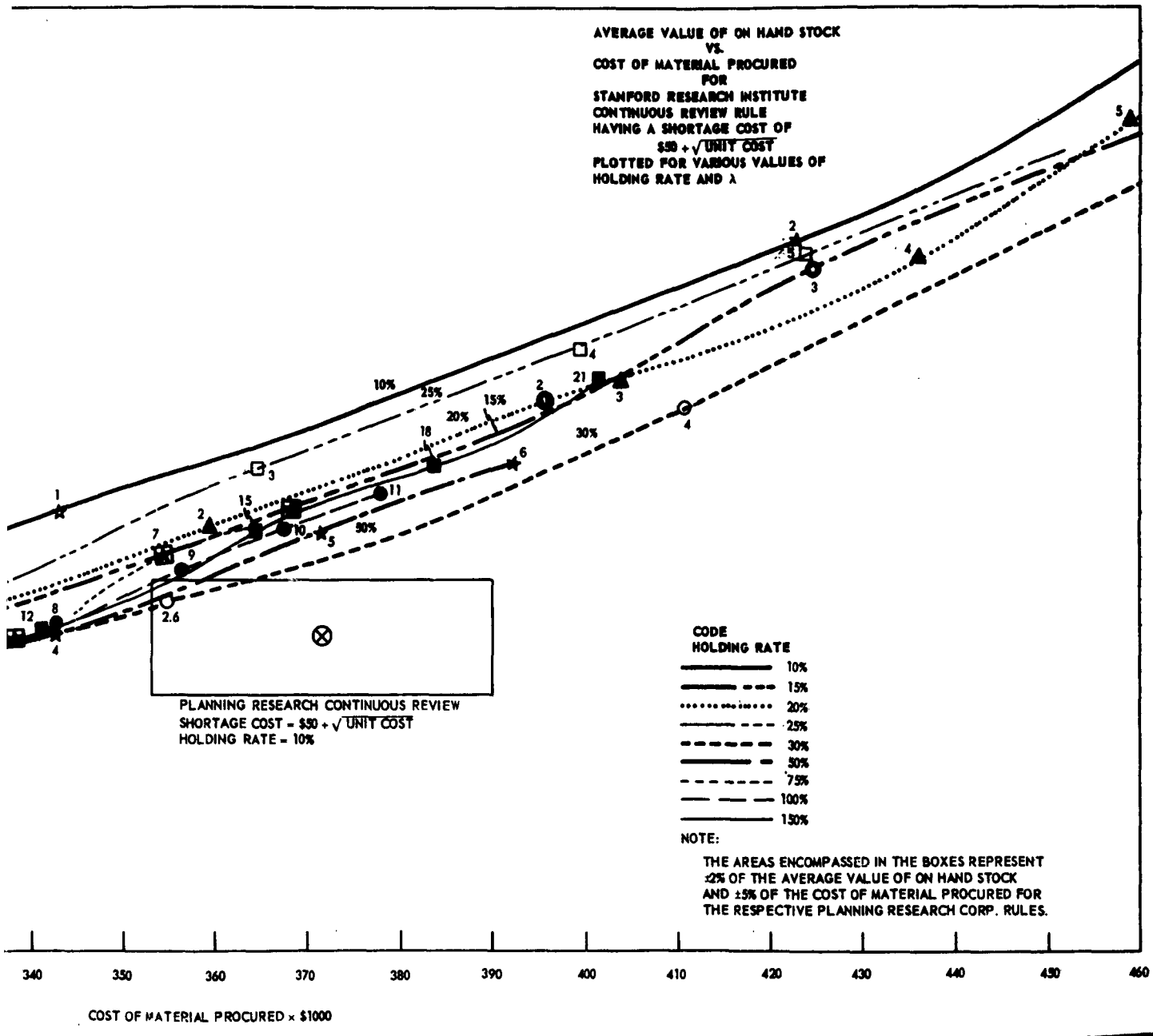


Figure 12. Average Inventory vs Material Procured, SRI Rules (C



vs Material Procured, SRI Rules (Continuous \$50 + $\sqrt{\text{Unit Cost}}$)

2

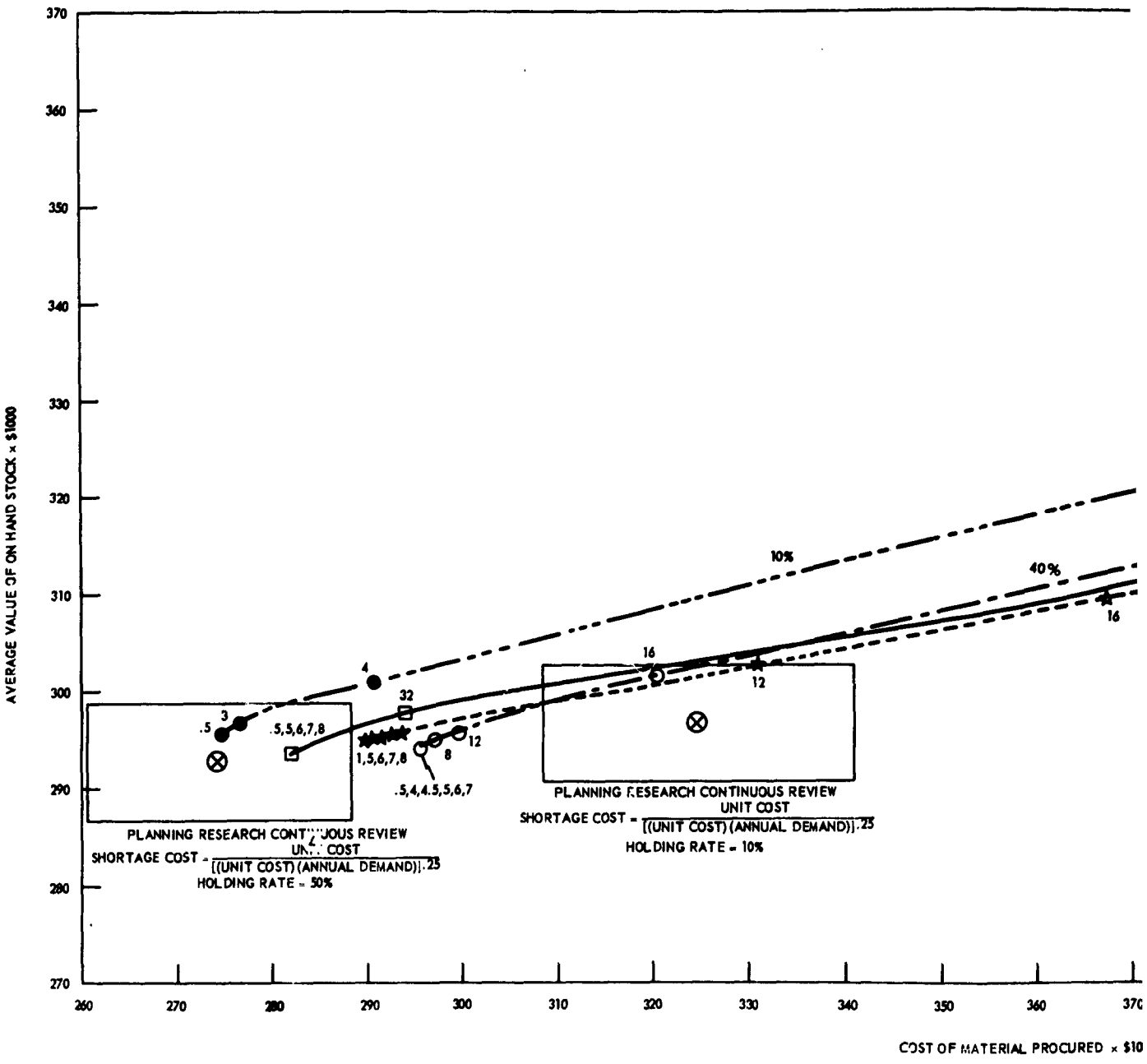
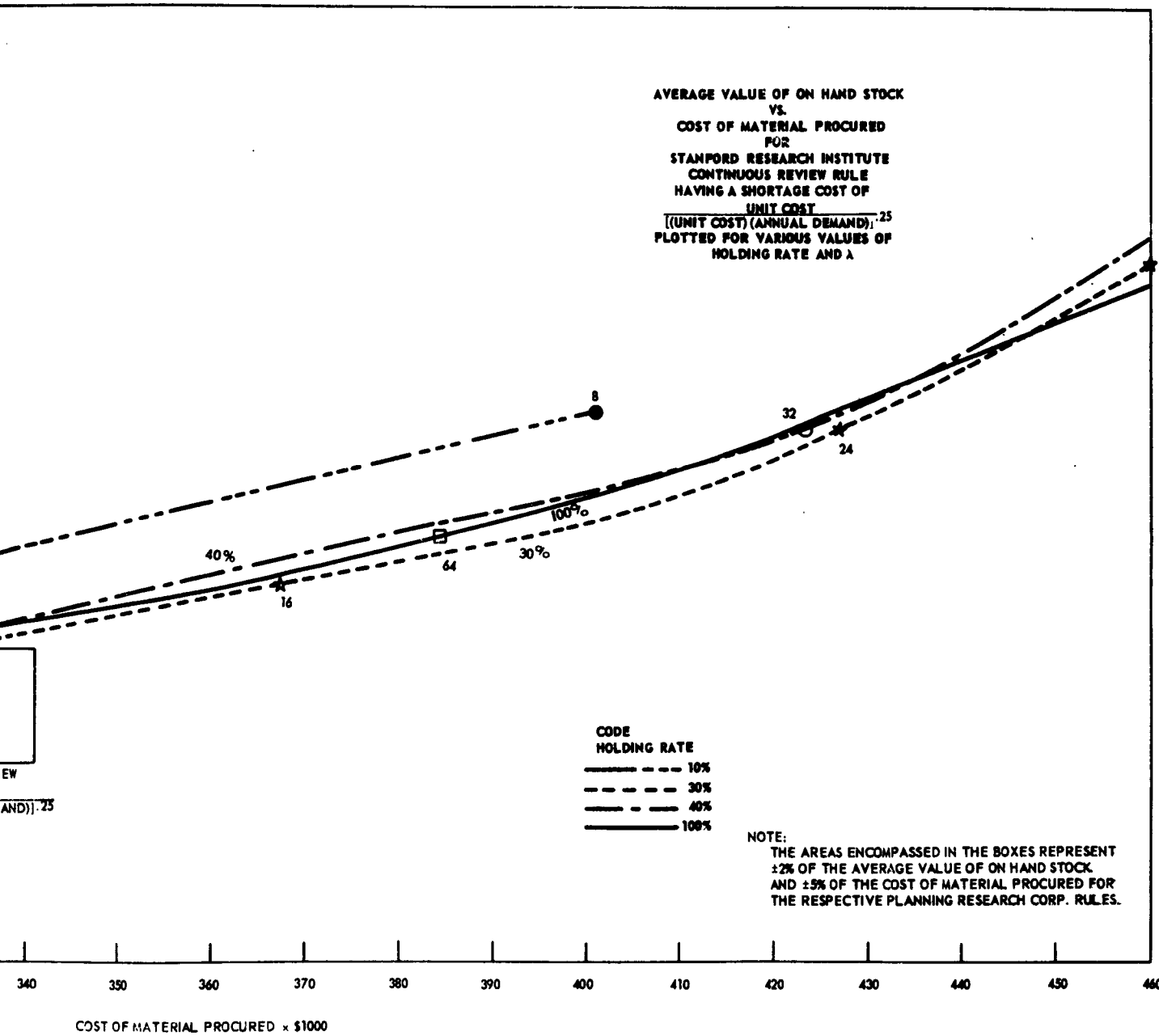


Figure 13. Average Inventory vs Material Procured, SRI Rules (Continuou



Procured, SRI Rules (Continuous) $\{(\text{Unit Cost})/[(\text{Unit Cost})\ (\text{Annual Demand})]^{.25}\}$

2

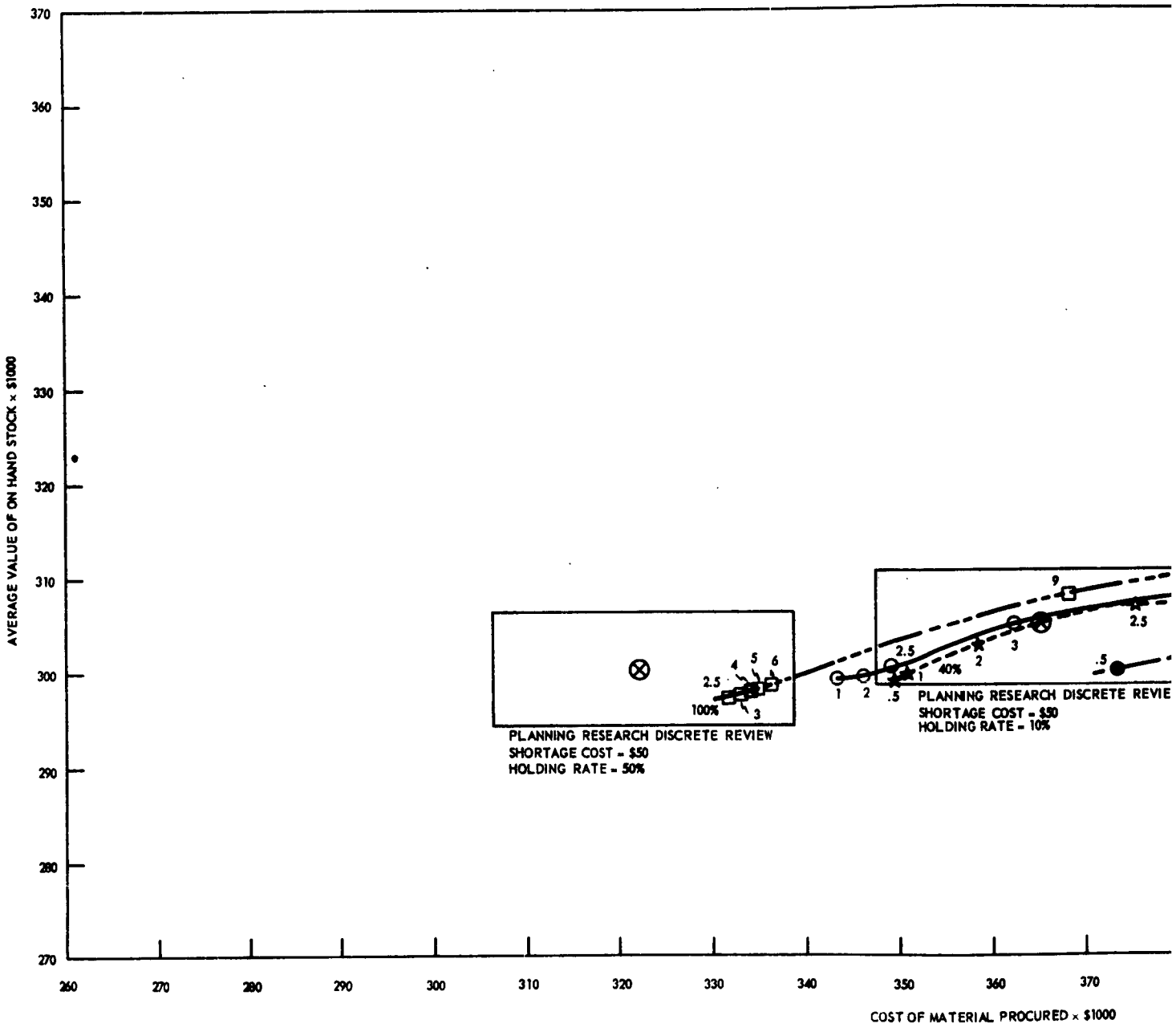
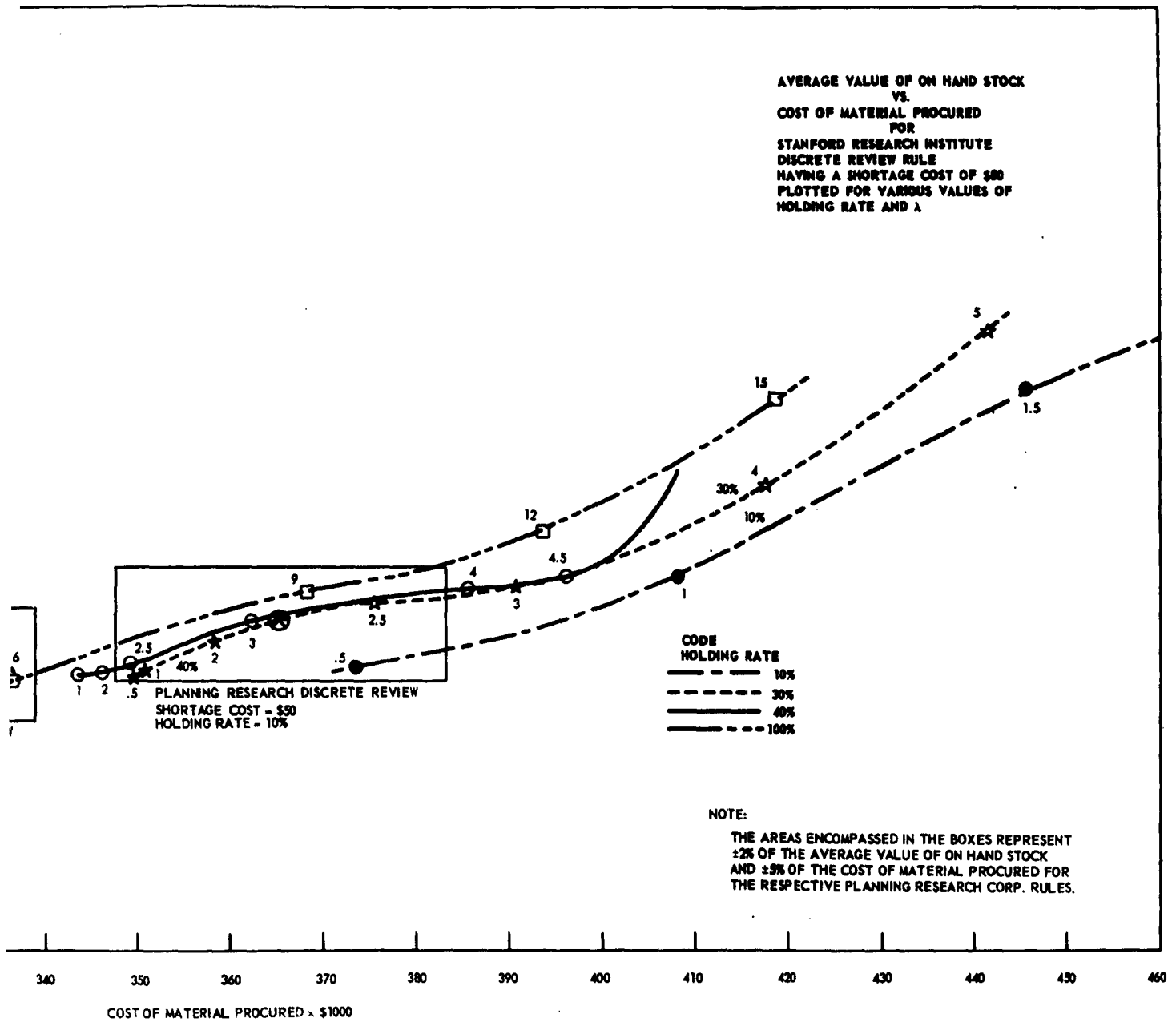


Figure 14. Average Inventory vs Material Procured, SRI R



ge Inventory vs Material Procured, SRI Rules (Discrete $50)

2

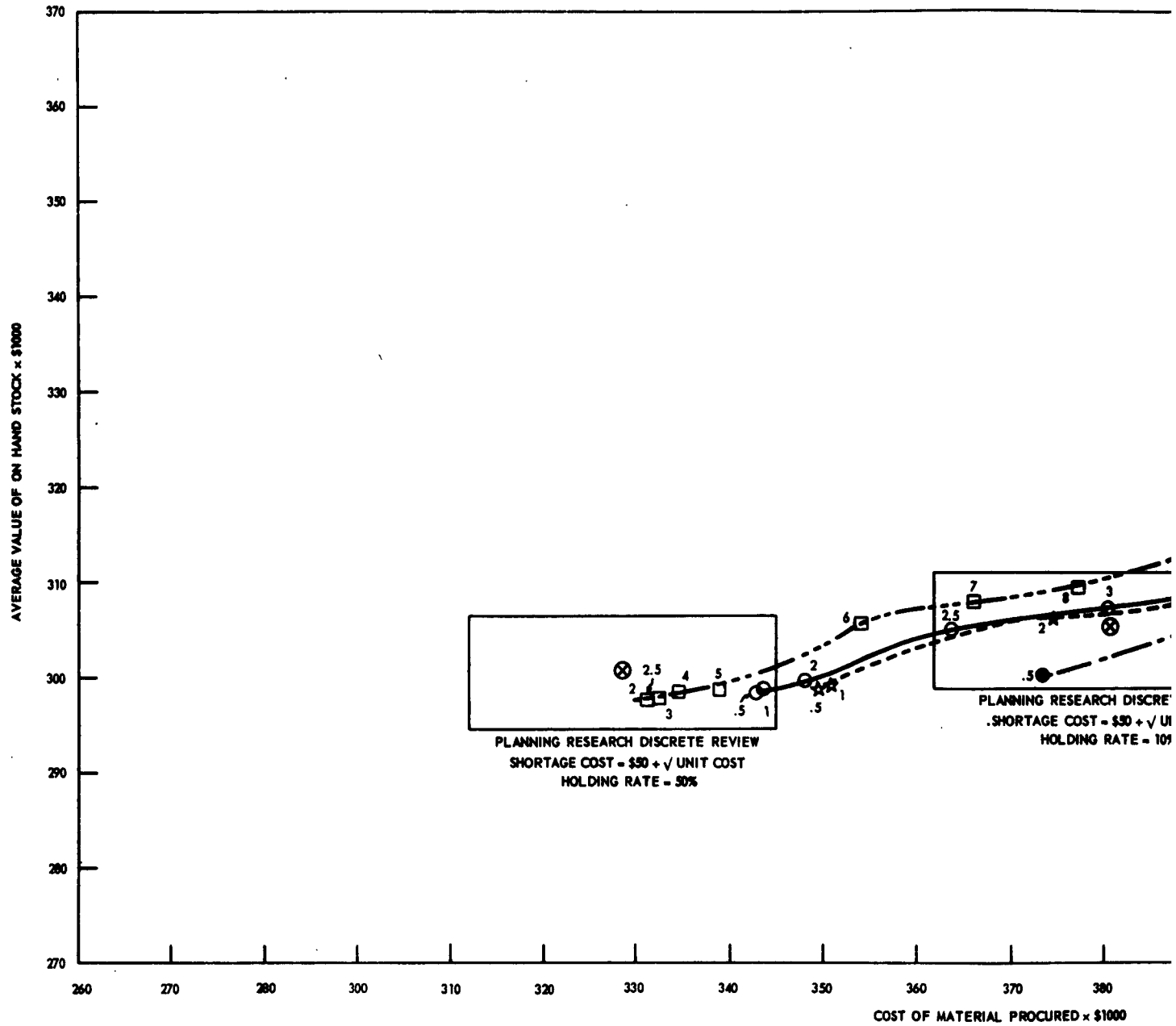
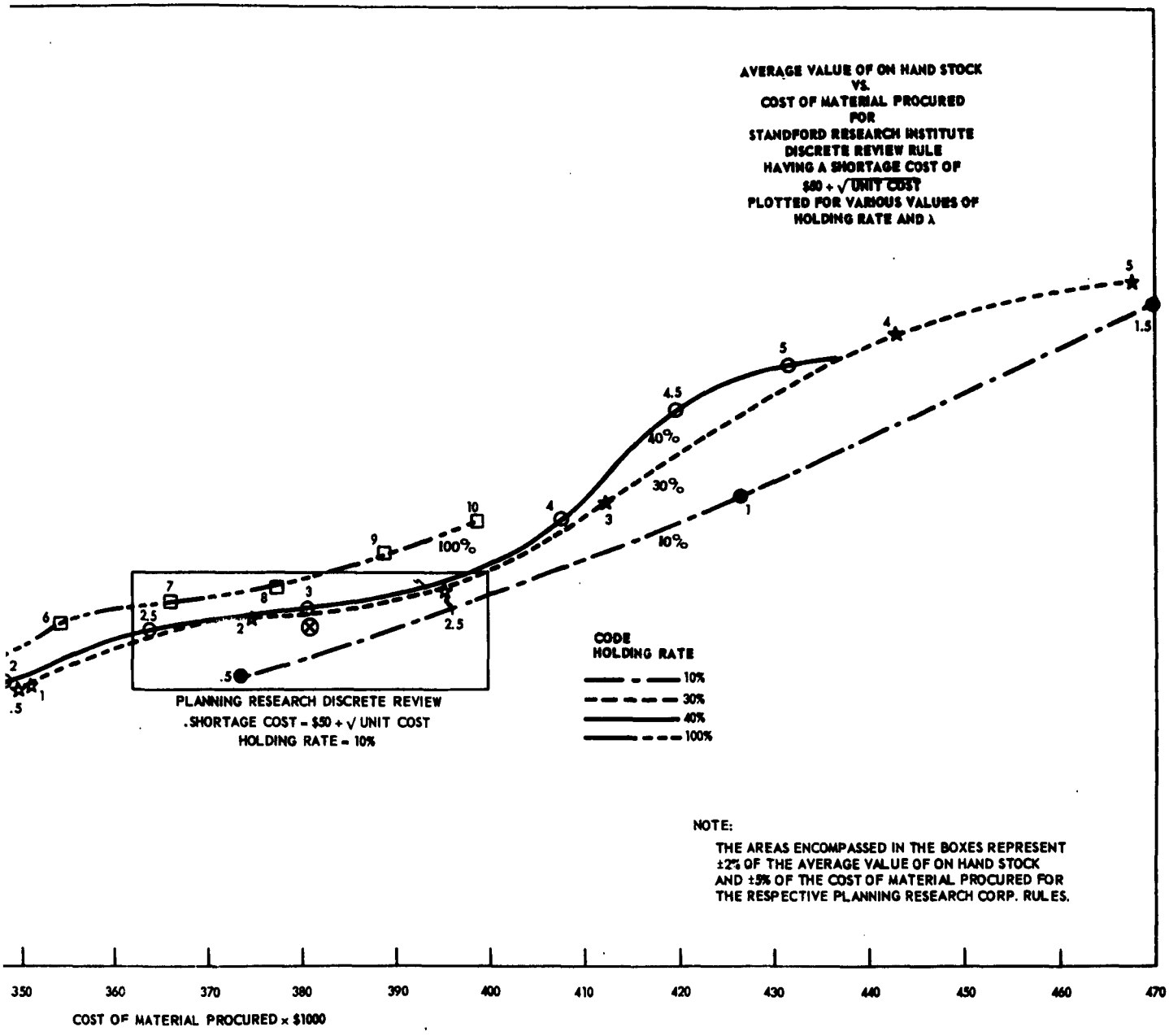


Figure 15. Average Inventory vs Material Procured, SRI Rules (



ry vs Material Procured, SRI Rules (Discrete $50 + $\sqrt{\text{Unit Cost}}$)

2

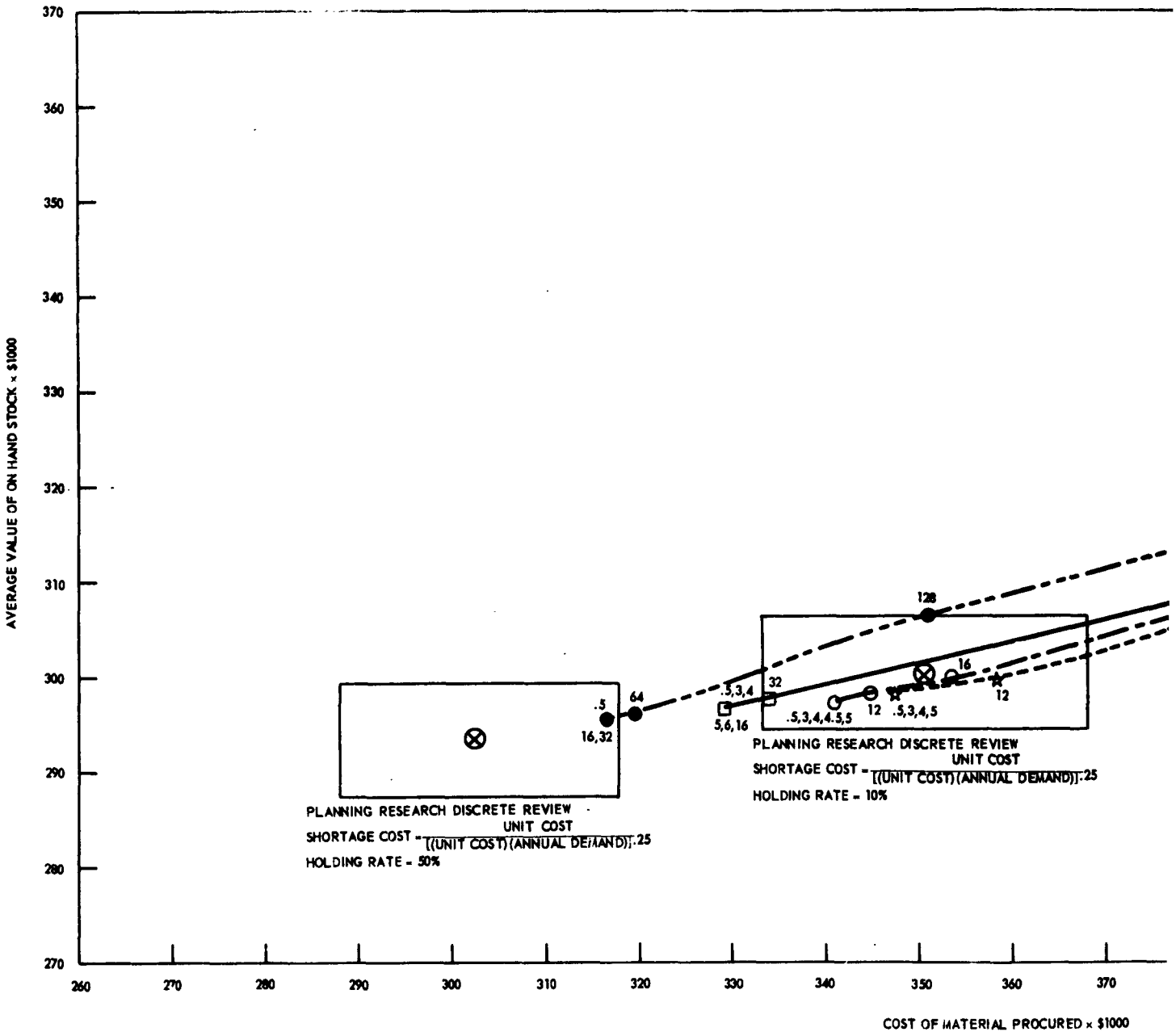
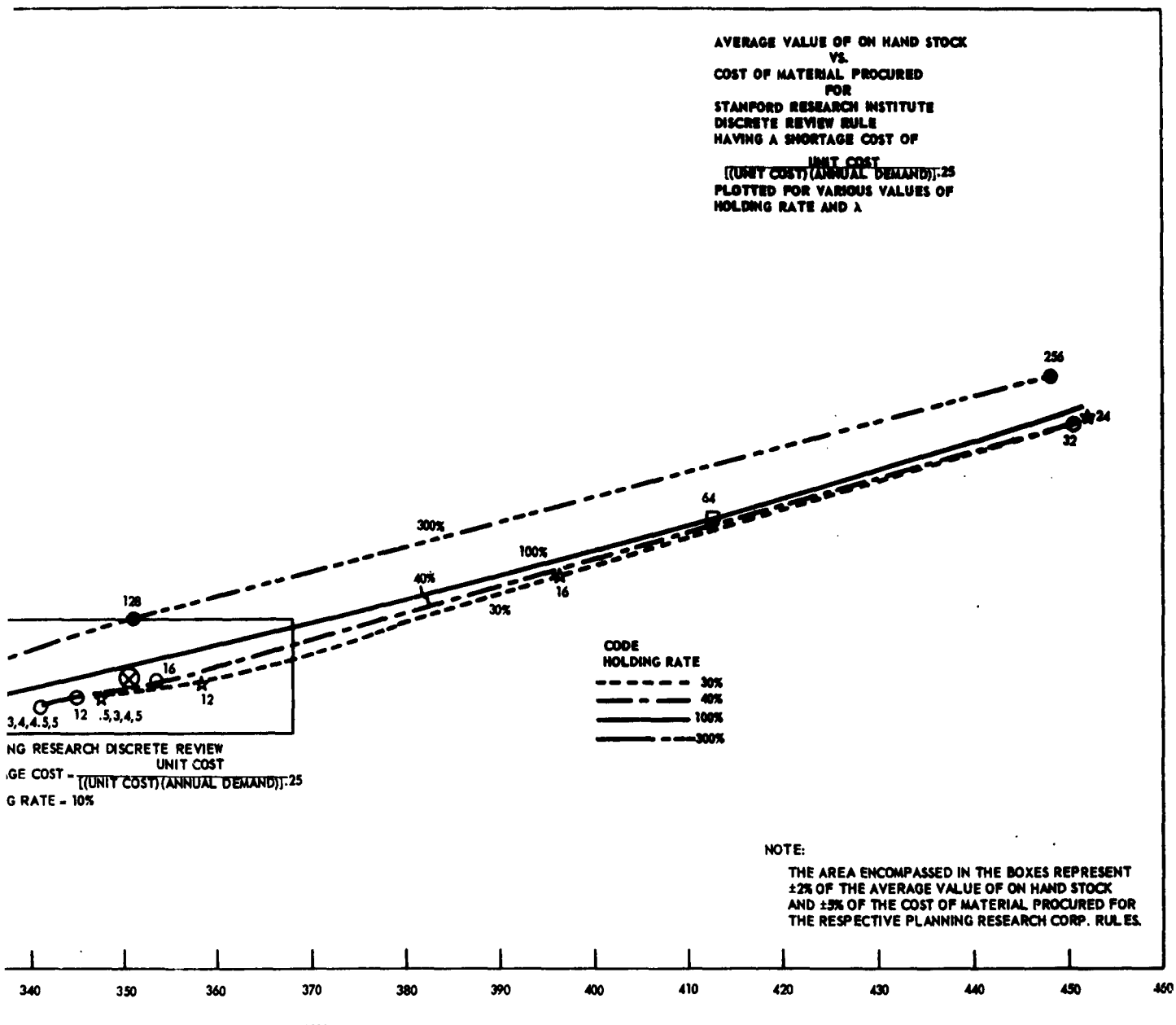


Figure 16. Average Inventory vs Material Procured, SRI Rules (Discrete) { (L



al Procured, SRI Rules (Discrete) $\{(\text{Unit Cost})/[(\text{Unit Cost})(\text{Annual Demand})]^{.25}\}$

Section 4

RESULTS AND CONCLUSIONS

Through the use of the IBM Inventory Management Simulator, it was possible to vary the values of λ and H in the SRI rules and match results of using inventory decision rules developed by PRC.

Twelve combinations of PRC rules were held constant. By varying the SRI rules, it was demonstrated that in every case the average values of the on-hand stock could be brought within plus or minus 2 percent, and the cost of material procured within plus or minus 5 percent of that obtained by using corresponding PRC rules.

The following conclusions were reached.

(1) In all cases analyzed as the value of the Lagrangian multiplier (λ) is increased, both the cost of material procured and the average value of on-hand stock increase.

(2) As λ decreases, a minimum point is reached when λ becomes so small that the minimum order point restriction is initiated for each of the items.

(3) Variations in λ effect order point but not order quantity.

(4) Increasing the holding rate while keeping λ constant decreases the order quantity and decreases the order point.

(5) The various system simulation values of the ratio of λ/H yielded approximately equivalent values for cost of material procured and average value of on-hand stock. As the values of λ/H increased, values for cost of material procured and average value of on-hand stock increased.

REFERENCES

1. Magee, John F., Production Planning and Inventory Control, McGraw-Hill Book Company, Inc., New York, 1958.
2. Brown, Robert G., Statistical Forecasting for Inventory Control, McGraw-Hill Book Company, Inc., New York, 1959.
3. An Introduction to Variable Stock Levels, Bureau of Supplies and Accounts, Washington, D. C., 1960.
4. Hildebrand, W. J., Theory and Application of the Negative Binomial Distribution to the Inventory Control Problem, Ships Parts Control Center, Mechanicsburg, Pa., 1960.
5. Reference Manual 709/7090 FORTRAN, Programming System, IBM Corporation, 1961.
6. Program Sixty-One, A Basic Training Course in Inventory Control, Ships Parts Control Center, Mechanicsburg, Pa., 1961.
7. Ridgeway, A. O., Grossman, R. E., and Portman, J. L., Use of the IBM Inventory Management Simulator in a Military Supply System, Federal Systems Division, IBM Corporation, 1961.
8. Pearson, Karl, Tables of the Incomplete Gamma Function, Cambridge University Press, London, 1934.
9. Dixon, W. J., Massey, F. J., Introduction to Statistical Analysis, McGraw-Hill Book Company, Inc., New York, 1957.
10. The Development and Implementation of Advanced Inventory Control Procedures, Stanford Research Institute, Menlo Park, California, 1960.
11. Modification to the Interim Model Procurement Rules and Item Balance Factor in the Interim Model Procurement Rules, Stanford Research Institute, Menlo Park, California, 1961.

Appendix

Generation of Variable Lead Times—Normal Distribution

Generation of Variable Lead Times
Normal Distribution

Item No. 1 Fed. Stock No. HF-2010-385-9501

μ_L = Mean Lead Time (days) 330 (47 weeks) σ_L (days) 18 (2.57 weeks)

$\frac{X - \mu_L}{\sigma_L} = t(v)$ where t(v) is the random normal number

$X = (\sigma_L)(t(v)) + \mu_L$

Sample No.	Random Normal No. t(v)	$(\sigma_L)(t(v))$	Lead Time (days) X	Lead Time (weeks)
1	+1.464	+26.352	356.35	51
2	+1.137	+20.466	350.47	50
3	+2.455	+44.190	374.19	54
4	-0.323	- 5.814	324.19	46
5	-0.068	- 1.224	328.78	47
6	+0.296	+ 5.328	335.33	48
7	-0.288	- 5.184	324.82	46
8	+1.298	+23.364	353.36	50
9	+0.241	+ 4.338	334.34	48
10	-0.957	-17,226	312.77	45

Generation of Variable Lead Times
Normal Distribution

Item No. 2 Fed. Stock No. HF-2030-318-7319

μ_L = Mean Lead Time (days) 330 (47 weeks) . σ_L (days) 17 (2.43 weeks)

$\frac{X - \mu_L}{\sigma_L} = t(v)$ where t(v) is the random normal number

$X = (\sigma_L)(t(v)) + \mu_L$

Sample No.	Random Normal No. t(v)	$(\sigma_L)(t(v))$	Lead Time (days) X	Lead Time (weeks)
1	-1.329	-22.593	307.41	44
2	-0.238	- 4.046	325.95	47
3	-0.838	-14.246	315.75	45
4	-0.988	-16.796	313.20	45
5	-0.445	- 7.565	322.43	46
6	+0.964	+16.388	346.39	50
7	-0.266	- 4.522	325.48	47
8	-0.322	- 5.474	324.53	46
9	-1.726	-29.342	300.66	43
10	+2.252	+38.284	368.28	53

Generation of Variable Lead Times
Normal Distribution

Item No. 3 Fed. Stock No. HF-2040-393-3842

μ_L = Mean Lead Time (days) 271 (39 weeks) σ_L (days) 17 (2.43 weeks)

$\frac{X - \mu_L}{\sigma_L} = t(v)$ where t(v) is the random normal number

$X = (\sigma_L)(t(v)) + \mu_L$

Sample No.	Random Normal No. t(v)	$(\sigma_L)(t(v))$	Lead Time (days) X	Lead Time (weeks)
1	-1.752	-29.784	241.22	34
2	-0.329	- 5.593	265.41	38
3	-1.256	-21.352	249.65	36
4	+0.318	+ 5.406	276.41	40
5	+1.531	+26.027	297.03	42
6	+0.349	+ 5.933	276.93	40
7	-0.958	-16.286	254.71	36
8	-0.059	- 1.003	270.00	39
9	+0.415	+ 7.055	278.06	40
10	-1.084	-18.428	263.94	38

Generation of Variable Lead Times
Normal Distribution

Item No. 4 Fed. Stock No. HF-2805-275-3061

μ_L = Mean Lead Time (days) 240 (34 weeks) σ_L (days) 19 (2.71 weeks)

$\frac{X - \mu_L}{\sigma_L} = t(v)$ where t(v) is the random normal number

$X = (\sigma_L)(t(v)) + \mu_L$

Sample No.	Random Normal No. t(v)	$(\sigma_L)(t(v))$	Lead Time (days) X	Lead Time (weeks)
1	+0.756	+14.364	254.36	36
2	-0.860	-16.340	223.66	32
3	-0.778	-14.782	225.22	32
4	+0.037	+ 0.703	240.70	34
5	+2.619	+49.761	289.76	41
6	-0.420	- 7.980	232.02	33
7	+1.048	+19.912	259.91	37
8	+1.000	+19.000	259.00	37
9	+0.170	+ 3.230	243.23	35
10	+0.389	+ 7.391	247.39	35

Generation of Variable Lead Times
Normal Distribution

Item No. 5 Fed. Stock No. HF-2805-333-0992

μ_L = Mean Lead Time (days) 330 (47 weeks) σ_L (days) 21 (3.0 weeks)

$\frac{X - \mu_L}{\sigma_L} = t(v)$ where t(v) is the random normal number

$X = (\sigma_L)(t(v)) + \mu_L$

Sample No.	Random Normal No. t(v)	$(\sigma_L)(t(v))$	Lead Time (days) X	Lead Time (weeks)
1	-0.305	- 6.405	323.59	46
2	-0.321	- 6.741	323.26	46
3	+1.900	+39.900	369.90	51
4	-0.778	-16.338	313.66	45
5	+0.617	+12.957	352.96	50
6	-1.430	-30.030	299.97	43
7	+0.267	+ 5.607	335.61	48
8	+0.978	+20.538	350.54	50
9	-1.235	-25.935	304.06	43
10	-0.258	- 5.418	324.58	46

Generation of Variable Lead Times
Normal Distribution

Item No. 6 Fed. Stock No. HF-2815-179-8683

μ_L = Mean Lead Time (days) 600 (86 weeks) σ_L (days) 19 (2.71 weeks)

$\frac{X - \mu_L}{\sigma_L} = t(v)$ where t(v) is the random normal number

$X = (\sigma_L)(t(v)) + \mu_L$

Sample No.	Random Normal No. t(v)	$(\sigma_L)(t(v))$	Lead Time (days) X	Lead Time (weeks)
1	+0.243	+ 4.617	604.62	86
2	-0.292	- 5.548	594.45	85
3	-0.505	- 9.595	590.40	84
4	+0.397	+ 7.543	607.54	87
5	-0.605	-11.495	588.50	84
6	+1.360	+25.840	625.84	89
7	+0.480	+ 9.120	609.12	87
8	-0.027	- 0.513	599.49	86
9	-1.482	-28.158	571.84	82
10	-1.256	-23.864	576.14	82

Generation of Variable Lead Times
Normal Distribution

Item No. 7 Fed. Stock No. HF-2815-343-2678

μ_L = Mean Lead Time (days) 290 (41 weeks) σ_L (days) 19 (2.71 weeks)

$\frac{X - \mu_L}{\sigma_L} = t(v)$ where t(v) is the random normal number

$X = (\sigma_L)(t(v)) + \mu_L$

Sample No.	Random Normal No. t(v)	$(\sigma_L)(t(v))$	Lead Time (days) X	Lead Time (weeks)
1	-1.132	-21.508	268.50	38
2	-0.780	-14.820	273.18	39
3	-0.859	-16.321	273.68	39
4	+0.447	+ 8.493	298.49	43
5	+0.269	+ 5.111	295.11	42
6	+0.097	+ 1.843	291.84	42
7	-0.686	-13.034	276.97	40
8	+0.957	+18.183	308.18	44
9	-0.976	-18.544	271.46	39
10	+0.274	+ 5.206	295.21	42

Generation of Variable Lead Times
Normal Distribution

Item No. 8 Fed. Stock No. HF-2815-354-1217

μ_L = Mean Lead Time (days) 330 (47 weeks) σ_L (days) 22 (3.14 weeks)

$\frac{X - \mu_L}{\sigma_L} = t(v)$ where t(v) is the random normal number

$X = (\sigma_L)(t(v)) + \mu_L$

Sample No.	Random Normal No. t(v)	$(\sigma_L)(t(v))$	Lead Time (days) X	Lead Time (weeks)
1	-0.397	- 8.734	321.27	46
2	+0.412	+ 9.064	339.06	48
3	-0.979	-21.538	308.46	44
4	+0.062	+ 1.364	331.36	47
5	-0.440	- 9.680	320.32	46
6	-0.287	- 6.314	323.69	46
7	+0.220	+ 4.840	334.84	48
8	-0.638	-14.036	315.96	45
9	-1.131	-24.882	307.12	44
10	-0.435	- 9.570	320.43	46

Generation of Variable Lead Times
Normal Distribution

Item No. 9 Fed. Stock No. HF-2815-364-3753

μ_L = Mean Lead Time (days) 330 (47 weeks) σ_L (days) 24 (3.43 weeks)

$\frac{X - \mu_L}{\sigma_L} = t(v)$ where t(v) is the random normal number

$X = (\sigma_L)(t(v)) + \mu_L$

Sample No.	Random Normal No. t(v)	$(\sigma_L)(t(v))$	Lead Time (days) X	Lead Time (weeks)
1	+0.838	+20.112	350.112	50
2	-0.039	- 0.936	320.64	46
3	+1.572	+37.728	367.73	53
4	-0.288	- 6.912	323.09	46
5	-1.718	-41.232	288.77	41
6	-0.953	-22.782	307.13	44
7	-0.048	- 1.152	318.48	45
8	-0.520	-12.480	317.52	45
9	-1.168	-28.032	301.97	43
10	+0.638	+15.312	345.312	49

Generation of Variable Lead Times
Normal Distribution

Item No. 10 Fed. Stock No. HF-2815-391-6903

μ_L = Mean Lead Time (days) 330 (47 weeks) σ_L (days) 19 (2.71 weeks)

$\frac{X - \mu_L}{\sigma_L} = t(v)$ where t(v) is the random normal number

$X = (\sigma_L)(t(v)) + \mu_L$

Sample No.	Random Normal No. t(v)	$(\sigma_L)(t(v))$	Lead Time (days) X	Lead Time (weeks)
1	+0.629	+11.951	341.95	49
2	-1.455	-27.645	302.35	43
3	+0.389	+ 7.391	337.39	48
4	-0.287	- 5.453	324.55	46
5	-0.470	- 8.930	321.07	46
6	+0.182	+ 3.458	333.46	48
7	-0.699	-13.281	316.72	45
8	-0.487	- 9.253	320.75	46
9	-0.815	-15.385	314.51	45
10	-0.567	-10.773	319.23	46

Generation of Variable Lead Times
Normal Distribution

Item No. 11 Fed. Stock No. HF-2825-036-3215

μ_L = Mean Lead Time (days) 268 (38 weeks) σ_L (days) 17 (2.43 weeks)

$\frac{X - \mu_L}{\sigma_L} = t(v)$ where t(v) is the random normal number

$X = (\sigma_L)(t(v)) + \mu_L$

Sample No.	Random Normal No. t(v)	$(\sigma_L)(t(v))$	Lead Time (days) X	Lead Time (weeks)
1	+2.039	+34.663	302.66	43
2	-0.239	- 4.063	263.94	38
3	-0.215	- 3.655	264.34	38
4	+1.479	+25.143	293.14	42
5	+0.735	+12.495	280.50	40
6	-1.883	-32.011	235.99	34
7	-1.596	-27.132	240.87	34
8	+0.057	+ .969	268.97	38
9	-1.789	-30.413	237.49	34
10	+0.226	+ 3.842	271.84	39

Generation of Variable Lead Times
Normal Distribution

Item No. 12 Fed. Stock No. HF-2825-126-4661

μ_L = Mean Lead Time (days) 420 (60 weeks) σ_L (days) 20 (2.86 weeks)

$\frac{X - \mu_L}{\sigma_L} = t(v)$ where t(v) is the random normal number

$X = (\sigma_L)(t(v)) + \mu_L$

Sample No.	Random Normal No. t(v)	$(\sigma_L)(t(v))$	Lead Time (days) X	Lead Time (weeks)
1	-1.772	-35.440	384.56	55
2	-0.327	- 6.540	413.46	59
3	+0.236	+ 4.720	424.72	61
4	+0.426	+ 8.510	428.51	61
5	+0.477	+ 9.540	429.54	61
6	-0.050	- 1.000	419.00	60
7	+1.121	+22.420	442.42	63
8	+1.261	+25.220	445.22	64
9	-0.985	-19.700	400.30	57
10	+0.171	+ 3.420	423.42	60

Generation of Variable Lead Times
Normal Distribution

Item No. 13 Fed. Stock No. HF-2825-147-8831

μ_L = Mean Lead Time (days) 264 (38 weeks) σ_L (days) 16 (2.29 weeks)

$\frac{X - \mu_L}{\sigma_L} = t(v)$ where t(v) is the random normal number

$X = (\sigma_L)(t(v)) + \mu_L$

Sample No.	Random Normal No. t(v)	$(\sigma_L)(t(v))$	Lead Time (days) X	Lead Time (weeks)
1	-2.019	-32.304	231.70	33
2	+1.799	+28.784	292.78	42
3	-0.244	- 3.904	260.10	37
4	-0.224	- 7.488	256.51	37
5	-0.183	- 2.928	261.07	37
6	+0.770	+12.320	278.32	40
7	+0.972	+15.552	279.55	40
8	-0.368	- 5.888	258.11	37
9	+0.325	+ 5.200	269.20	38
10	+2.309	+36.944	300.94	43

Generation of Variable Lead Times
Normal Distribution

Item No. 14 Fed. Stock No. HF-2825-216-9293

μ_L = Mean Lead Time (days) 287 (41 weeks) σ_L (days) 19 (2.71 weeks)

$\frac{X - \mu_L}{\sigma_L} = t(v)$ where t(v) is the random normal number

$X = (\sigma_L)(t(v)) + \mu_L$

Sample No.	Random Normal No. t(v)	$(\sigma_L)(t(v))$	Lead Time (days) X	Lead Time (weeks)
1	-1.516	-28.804	258.20	37
2	-1.451	-27.569	259.43	37
3	+0.544	+10.336	297.34	42
4	+1.712	+32.528	319.53	46
5	+0.007	+ .133	287.13	41
6	+1.476	+28.044	315.04	45
7	+1.615	+30.685	217.69	31
8	-1.000	-19.000	268.00	38
9	-0.121	- 2.299	284.70	41
10	-0.994	-18.886	268.13	38

Generation of Variable Lead Times
Normal Distribution

Item No. 15 Fed. Stock No. HR-2825-379-3571

μ_L = Mean Lead Time (days) 540 (77 weeks) σ_L (days) 24 (3.43 weeks)

$\frac{X - \mu_L}{\sigma_L} = t(v)$ where t(v) is the random normal number

$X = (\sigma_L)(t(v)) + \mu_L$

Sample No.	Random Normal No. t(v)	$(\sigma_L)(t(v))$	Lead Time (days) X	Lead Time (weeks)
1	+1.934	+46.416	596.42	85
2	-0.497	-11.928	528.07	75
3	+0.241	+ 5.784	545.78	78
4	+0.067	+ 1.608	541.61	77
5	-0.066	- 1.584	538.42	77
6	-0.218	- 5.232	534.77	76
7	-0.286	- 6.864	533.14	76
8	-1.153	-27.672	512.33	73
9	-0.696	-16.704	523.30	75
10	-0.909	-21.816	518.14	74

Generation of Variable Lead Times
Normal Distribution

Item No. 16 Fed. Stock No. HS-2825-388-1584

μ_L = Mean Lead Time (days) 363 (52 weeks) σ_L (days) 21 (3.0 weeks)

$\frac{X - \mu_L}{\sigma_L} = t(v)$ where t(v) is the random normal number

$X = (\sigma_L)(t(v)) + \mu_L$

Sample No.	Random Normal No. t(v)	$(\sigma_L)(t(v))$	Lead Time (days) X	Lead Time (weeks)
1	-0.257	- 5.397	357.60	51
2	+9.178	+ 3.738	366.74	52
3	-1.033	-21.693	341.31	49
4	+1.221	+25.620	388.62	56
5	+1.063	+22.323	385.32	55
6	-0.481	-10.101	352.90	50
7	-1.789	-37.569	325.43	46
8	+0.510	+10.710	373.71	53
9	+0.102	+ 2.142	365.14	52
10	+0.891	+18.711	381.71	54

Generation of Variable Lead Times
Normal Distribution

Item No. 17 Fed. Stock No. HS-2825-394-8584

μ_L = Mean Lead Time (days) 330 (47 weeks) σ_L (days) 20 (2.86 weeks)

$\frac{X - \mu_L}{\sigma_L} = t(v)$ where t(v) is the random normal number

$X = (\sigma_L)(t(v)) + \mu_L$

Sample No.	Random Normal No. t(v)	$(\sigma_L)(t(v))$	Lead Time (days) X	Lead Time (weeks)
1	-0.540	-10.800	319.20	46
2	-1.032	-20.640	309.36	44
3	-1.721	-34.420	295.58	42
4	-1.324	-26.480	303.52	43
5	-0.100	- 2.000	328.00	47
6	-0.007	- .140	329.86	47
7	+0.734	+14.680	344.68	49
8	+1.690	+33,800	363.80	52
9	+1.421	+28.420	358.42	51
10	+0.741	+14.820	344.82	49

Generation of Variable Lead Times
Normal Distribution

Item No. 18 Fed. Stock No. HF-2910-364-2072

μ_L = Mean Lead Time (days) 330 (47 weeks) σ_L (days) 19 (2.71 weeks)

$\frac{X - \mu_L}{\sigma_L} = t(v)$ where t(v) is the random normal number

$X = (\sigma_L)(t(v)) + \mu_L$

Sample No.	Random Normal No. t(v)	$(\sigma_L)(t(v))$	Lead Time (days) X	Lead Time (weeks)
1	-0.157	- 2.983	327.02	47
2	+1.492	+28.348	358.35	51
3	-0.042	- .798	329.20	47
4	+0.289	+ 5.491	335.49	48
5	+0.721	+13.699	343.70	49
6	-0.599	-11.381	318.62	46
7	-0.225	- 4.275	325.72	47
8	-0.015	- .285	327.10	47
9	+1.884	+35.796	365.80	52
10	+1.011	+19.209	349.21	50

Generation of Variable Lead Times
Normal Distribution

Item No. 19 Fed. Stock No. HF-2920-640-7546

μ_L = Mean Lead Time (days) 389 (56 weeks) σ_L (days) 19 (2.71 weeks)

$\frac{X - \mu_L}{\sigma_L} = t(v)$ where t(v) is the random normal number

$X = (\sigma_L)(t(v)) + \mu_L$

Sample No.	Random Normal No. t(v)	$(\sigma_L)(t(v))$	Lead Time (days) X	Lead Time (weeks)
1	-0.222	- 4.218	384.78	55
2	-0.434	- 8.246	380.75	54
3	+1.471	+27.949	416.95	60
4	+0.426	+ 8.094	397.09	57
5	-0.271	- 5.149	383.85	55
6	+0.202	+ 3.838	392.84	56
7	+0.722	+13.718	402.72	58
8	+0.701	+13.319	402.31	57
9	-1.799	-34.181	354.82	51
10	-0.572	-10.868	378.13	54

Generation of Variable Lead Times
Normal Distribution

Item No. 20 Fed. Stock No. HF-2930-363-8598

μ_L = Mean Lead Time (days) 360 (51 weeks) σ_L (days) 20 (2.86 weeks)

$\frac{X - \mu_L}{\sigma_L} = t(v)$ where t(v) is the random normal number

$X = (\sigma_L)(t(v)) + \mu_L$

Sample No.	Random Normal No. t(v)	$(\sigma_L)(t(v))$	Lead Time (days) X	Lead Time (weeks)
1	+1.120	+22.400	382.40	55
2	+0.524	+10.480	370.48	53
3	+1.497	+29.940	389.94	56
4	+0.471	+ 9.420	369.42	53
5	+0.320	+ 6.400	366.40	52
6	+1.521	+30.420	390.42	56
7	-1.211	-24.220	335.78	48
8	-0.150	- 3.000	357.00	51
9	-0.939	-18.780	341.22	49
10	+1.158	+23.160	383.16	55

Generation of Variable Lead Times
Normal Distribution

Item No. 21 Fed. Stock No. HS-3110-100-5507

μ_L = Mean Lead Time (days) 330 (47 weeks) σ_L (days) 20 (2.86 weeks)

$\frac{X - \mu_L}{\sigma_L} = t(v)$ where t(v) is the random normal number

$X = (\sigma_L)(t(v)) + \mu_L$

Sample No.	Random Normal No. t(v)	$(\sigma_L)(t(v))$	Lead Time (days) X	Lead Time (weeks)
1	+0.905	+18.100	348.10	50
2	-2.225	-44.500	285.50	41
3	+1.130	+22.600	352.60	50
4	-0.072	- 1.440	328.56	47
5	+1.719	+34.380	364.38	52
6	-1.872	-37.440	292.56	42
7	-1.408	-28.160	301.84	43
8	-1.479	-29.580	300.42	43
9	+2.652	+53.040	383.04	55
10	-0.161	- 3.220	326.78	47

Generation of Variable Lead Times
Normal Distribution

Item No. 22 Fed. Stock No. HF-3610-394-9234

μ_L = Mean Lead Time (days) 330 (47 weeks) σ_L (days) 22 (3.14 weeks)

$\frac{X - \mu_L}{\sigma_L} = t(v)$ where t(v) is the random normal number

$X = (\sigma_L)(t(v)) + \mu_L$

Sample No.	Random Normal No. t(v)	$(\sigma_L)(t(v))$	Lead Time (days) X	Lead Time (weeks)
1	+0.693	+15.246	342.25	49
2	-0.713	-15.686	314.31	45
3	+1.615	+34.530	365.53	52
4	-0.904	-19.888	310.11	44
5	-1.117	-24.574	305.43	44
6	-0.875	-19.250	310.75	44
7	+1.014	+22.308	352.31	50
8	+0.119	+ 2.618	332.62	48
9	-0.185	- 4.070	325.93	47
10	-1.071	-23.562	306.44	44

Generation of Variable Lead Times
Normal Distribution

Item No. 23 Fed. Stock No. HF-3610-491-2255

μ_L = Mean Lead Time (days) 330 (47 weeks) . σ_L (days) 18 (2.57 weeks)

$\frac{X - \mu_L}{\sigma_L} = t(v)$ where t(v) is the random normal number

$X = (\sigma_L)(t(v)) + \mu_L$

Sample No.	Random Normal No. t(v)	$(\sigma_L)(t(v))$	Lead Time (days) X	Lead Time (weeks)
1	+0.386	+ 6.948	336.95	48
2	-0.284	- 5.112	324.89	47
3	+0.389	+ 7.002	337.00	48
4	-0.370	- 6.660	323.34	46
5	-1.439	-25.902	304.10	44
6	-0.357	- 6.426	323.57	46
7	+0.655	+11.790	341.79	49
8	-0.280	- 5.040	324.96	47
9	-0.354	- 6.372	323.63	46
10	+0.181	+ 1.448	331.45	47

Generation of Variable Lead Times
Normal Distribution

Item No. 24 Fed. Stock No. HF-3950-344-0817

μ_L = Mean Lead Time (days) 223 (32 weeks) σ_L (days) 16 (2.29 weeks)

$\frac{X - \mu_L}{\sigma_L} = t(v)$ where t(v) is the random normal number

$X = (\sigma_L)(t(v)) + \mu_L$

Sample No.	Random Normal No. t(v)	$(\sigma_L)(t(v))$	Lead Time (days) X	Lead Time (weeks)
1	+1.188	+19.008	242.01	35
2	-0.672	-10.752	212.25	30
3	-0.661	-10.576	212.42	30
4	+0.784	+12.544	235.54	34
5	+1.406	+22.496	245.50	35
6	-1.367	-21.872	201.13	29
7	-0.871	-13.936	209.06	30
8	+0.034	+ .544	223.54	32
9	-1.457	-23.312	199.69	29
10	+1.041	+16.656	239.66	34